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3 Years of Melon Variety Trials at Highmoor Farm, ME

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In 2017 we initiated a muskmelon cultivar trial promoted by the need to find melons that work well within the production restrictions of the state. Melons are a tropical fruit native to the Middle East and surrounding area. Being so, they require a considerable amount of heat and a long enough growing season to produce fruit. Newer melon cultivars have been developed for production in the region. These tend to have superior flavor compared to store bought melons shipped from more robust melon producing regions.

Generally, for muskmelons to thrive, soil and air temperatures must be between 65-75°F. Temperatures below 55°F will negatively affect the fruit. Soils composed of well-drained sandy loams with a slightly acidic pH work best. Lastly, watering requirements are moderate but are crucial in melon sizing as well as flavor. At our site, two out of the three years we grew these melons were considered drought years. Typical mean temperatures range between 60-70°F within the growing season, low night-time temperatures often hover around or drop below 55°F.

Muskmelons included in the trial where composed of eastern-shipping cantaloupes, tuscan, galia, honeydew and other specialty melon types. In all three years melons were started in a greenhouse in mid-May with an approximate target plant out date of three weeks. In 2017 plants were planted on 6/7/17 through black plastic at 18in in row spacing. The transplants were then covered with row cover until flowering. The same practice was carried out in year 2018 and 2019 on 6/15/18 and 6/22/19 respectively. Plants in 2019 went in considerably late due to growing issues in the greenhouse and were generally unhealthy upon planting. For this reason, summarized data was used from 2017 and 2018 of the trial. Data from year 2019 was only used when data was not available from another growing year.

Growers should take into consideration total yield, number, average melon weight, soluble solid content and type when choosing a melon that is marketable on your farm (Table 1). Based on our findings, farms looking for overall high yields might consider Passport (galia), Athena (cantaloupe) or Dream Dew (honeydew) as reliable options. If extra-large sized cantaloupes are desired, then Verona and Minerva would be a good fit based on our observations; however, these might be too big for some consumers. The small personal sized melons we trialed produced some of the highest numbers of fruit but had, as expected, less overall weight. This group also included the two melons with highest sugar content, Sugar Cube (Mini-Cantaloupe) and Serenade (Mini-Butterscotch). Passport (Galia) was our first melon to ripen after only 59 days from transplant. Those looking for an earlier cantaloupe might stick with Halona or Goddess.

Name	Type	No. Fruit /100ft	Yield lbs/100ft	Avg lbs/fruit	Avg. %SSC	Observed 1st harvest day from transplant	Harvest duration in days
Halona	Cantaloupe	211.3	562.3	2.66	11.2	66	5
Goddess	Cantaloupe	147.5	518.2	3.51	8.8	69	4
Cleopatra[a]	Cantaloupe	161.4	455.9	2.82	10.3	69	8
Verona	Cantaloupe	103.8	521.5	5.03	10.4	69	8
Sarah's Choice	Cantaloupe	92.5	323.8	3.50	10.9	69	11
Accolade	Cantaloupe	161.3	572.7	3.55	11.0	69	15
Shockwave	Cantaloupe	196.3	567.7	2.89	11.0	69	15
Grandslam[a]	Cantaloupe	117.5	435.3	3.70	11.5	69	17
Gold Star	Cantaloupe	188.8	562.6	2.98	11.9	69	15
Athena	Cantaloupe	185.0	651.0	3.52	12.4	69	15
Aphrodite	Cantaloupe	136.3	566.9	4.16	12.8	69	11
Ariel	Cantaloupe	147.5	514.7	3.49	9.8	71	13
Minerva	Cantaloupe	126.3	633.6	5.02	12.2	73	13
Wrangler	Cantaloupe / Tuscan	191.3	475.6	2.49	12.4	69	11
Divergent	Cantaloupe X Galia	138.8	436.2	3.14	13.9	69	15
Durasol	Canary	147.5	506.6	3.43	15.4	77	11
Passport	Galia	246.3	682.3	2.77	10.5	59	12
Diplomat	Galia	95.0	343.1	3.61	9.7	66	5
Masada	Galia	153.8	448.0	2.91	12.4	69	17
Dream Dew	Honeydew	146.3	644.0	4.40	10.5	71	15
Serenade	Mini-Butterscotch	330.0	438.7	1.33	16.5	71	13
Tasty Bites	Mini-Cantaloupe	273.8	350.4	1.28	11.8	66	11
Sugar Cube	Mini-Cantaloupe	230.0	345.3	1.50	15.8	69	17
Pixie[a]	Mini-Cantaloupe	216.3	301.3	1.39	9.8	72	9
Honey White	Mini-Honeydew	280.0	460.6	1.64	10.2	72	9
Snow Leopard	Variegated Honeydew	266.3	516.6	1.94	12.6	77	7

[a]Data used from 2019

Managing Multiple Diseases in Cucurbits: Fungicide Update

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

Fungicides are an important tool for managing diseases. Cultural practices, which include resistant varieties, are valuable components of an integrated management program, but typically when used without fungicides will not achieve sufficient control to avoid a reduction in yield or fruit quality. Fungicides recommended routinely change as new products are registered and pathogens develop resistance to fungicides that have been in use for several years. Modern fungicides because of their targeted mode of action typically have medium to high risk for resistance to develop in the pathogen. These need to be used in alternation to delay development of resistance, avoid control failure when resistance develops, and comply with label use restrictions. Some targeted fungicides have narrow activity necessitating applying multiple products when more than one disease is occurring. This is especially true with the most common diseases, powdery mildew (caused by a fungus) and downy mildew and Phytophthora blight (caused by oomycetes).

Powdery mildew. An integrated program with both management tools (resistant varieties and fungicides) is recommended to maximize likelihood of effective control. The pathogen has demonstrated ability to evolve and become less effectively controlled by both tools. Resistant varieties are now available in most crop groups with new varieties released most years. Resistance in cucumber is standard in modern varieties and is so strong it is easy to forget this cucurbit type is susceptible until an Heirloom type is grown. Resistance in other cucurbit crop types is not adequate used alone (without fungicide applications) to prevent impact of powdery mildew on yield. Alternate among targeted, mobile fungicides in the 5 chemical groups below (predominantly the first 3; all listed in recommended order), and apply with protectant fungicide to manage resistance development. Begin very early in disease development (one older leaf out of 50 with symptoms). Fungicide efficacy and occurrence of pathogen resistant strains are studied every year at LIHREC.

Vivando (FRAC Code 50) has continued to provide excellent control in fungicide evaluations. Activity is limited to powdery mildew. Do not mix with horticultural oils. It can be applied three times per year with no more than two consecutive applications. REI is 12 hr. PHI is 0 days. Prolivo is a new Code 50 fungicide; it was tested at LIHREC in 2016 and found not to be as effective as Quintec; Vivando was not included in that evaluation.

DMI fungicides (Code 3) include Proline, Procure, and Rhyme (these considered most effective) plus Aprovia Top, Folicur, Inspire Super, Mettle, Rally, Tebuzol, and TopGuard (also has Code 11 ingredient). Resistance is quantitative. Highest label rate is recommended because the pathogen has become less sensitive to this chemistry. Efficacy has varied in fungicide evaluations. Procure applied at its highest label rate provides a higher dose of active ingredient than the other Code 3 fungicides. Five applications can be made at this rate. REI is 12 hr for

these fungicides. PHI is 0 - 7 days. Powdery mildew is the only labeled cucurbit disease for some of these; see last section for additional labeled diseases.

Gatten is in a new fungicide group (Code U13). It was not as effective as Vivando in a fungicide evaluation at LIHREC in 2018.

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

Quintec (Code 13) was consistently effective in fungicide evaluations, although resistance was detected in 2015, until 2019. Activity is limited to powdery mildew. Label specifies no more than two consecutive applications plus a crop maximum of four applications, and no aerial applications. REI is 12 hr. PHI is 3 days. Limited use is suggested.

Resistance continues to be very common to MBC fungicides (FRAC code 1; Topsin M) and QoI fungicides (Code 11; Quadris, Cabrio and Flint); therefore these are not recommended. Torino (Code U6) failed in an experiment at LIHREC in 2017 due to resistance. Resistant pathogen strains were found in 2018 and 2019.

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

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

Biopesticides There are several products (Actinovate, Double Nickel, Regalia, RootShield, Serenade, SoilGard, Bio-Tam, etc.) that can be applied to soil pre-transplant, at planting, and via drip to manage the blight pathogen, *Phytophthora capsici*, in the root and crown zone and to induce resistance (Regalia). Most of these biopesticides can also be applied to foliage. They are approved for organic production. More information about managing Phytophthora blight is at http://vegetablemdonline.ppath.cornell.edu/NewsArticles/PhytoBlight_cucurbits-others.html for.

Downy mildew is primarily managed with fungicides. Cucumbers with a new source of resistance are becoming available. Those that performed well in variety evaluations are DMR 401, NY264, Bristol and Citadel, which is a pickling type suitable for fresh market. Some suppression, albeit variable, can be obtained with varieties bred to be resistant to pathogen strains present before 2004. An integrated program with fungicides applied to resistant varieties is recommend.

An important tool for determining when fungicide application is warranted is the forecast web site for this disease at http://cdm.ipmpipe.org. Cucurbit plants are susceptible to downy mildew from

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

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

As with powdery mildew, fungicide resistance is also a concern with the downy mildew pathogen and therefore the fungicide program recommended is also targeted, mobile fungicides applied in alternation based on FRAC Code (see list below) on a weekly schedule and tank mixed with a protectant fungicide (chlorothalonil or mancozeb) beginning very early in disease development. With both diseases expect recommendations to change as pathogens develop resistance to additional chemistry and new fungicides become available. So far resistance has been associated with pathogen affecting cucumber and melon. Fungicides described below as being affected by resistance may still be effective for downy mildew in other types of cucurbits.

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

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

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

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

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

Fungicides with documented or suspected resistance in the US. Resistance to Ranman was detected in the PB pathogen in the southeastern US. Resistance to others was detected in the DM pathogen affecting cucumber including in the northeastern US. These are no longer recommended for DM in cucumber and melon and recommended used sparingly (less than label limit which is listed below) for DM in squash and pumpkins and used for PB early in the season when DM is not a concern. Resistance has been identified based

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

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

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

Zampro (40, 45) and Revus (40). While in the same fungicide chemical group (40), there is indication they may have slightly different mode of action, thus there may be benefit to using one for the first application of a product in this group in a fungicide program and then switching to the other product later in the program. REI is 12 hr. PHI is 0 day. Apply no more than 3 times (4 for Revus) in a season with no more than 2 consecutive applications (no consecutive with Revus). Revus must be applied with a spreading/penetrating type adjuvant. Revus is recommended used sparingly because of suspected resistance. Forum is no longer recommended; it has the same FRAC Code 40 ingredient as Zampro.

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

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

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

Other diseases that can affect cucurbits and labeled fungicides.

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

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

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

Fusarium fruit and crown rot. Proline (3).

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

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

* Resistance detected in the US.

See http://vegetablemdonline.ppath.cornell.edu for more information about diseases of cucurbit crops and their management.

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

Weed Control in Cucurbit Crops

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Many growers use cultivation to control weeds before cucurbits start to run. Cultivation typically controls weeds in one of three ways – shallow severing, uprooting/drying, and burying. Newer cultivators have the ability to "stack" different implements together to achieve all three of these types of disturbance to kill weeds. My initial work with torsion weeders followed by finger weeders followed by a tine harrow showed that these tools interacted synergistically, but crop mortality was over 10% (Brown and Gallandt 2018b). In subsequent trials, with less aggressively adjusted sweeps, fingers, and disks, in-row weed mortality remained high while crop mortality was reduced to zero (Brown et al 2019). These results are encouraging but cultivation can usually only be used for the first half of the cucurbit's growth.

Due to their vining nature, cucurbits prevent tractors from entering the field to control late-season weeds. This often allows weeds to produce seed. Some growers that are not land-limited will rotate into hay for a few years to bring the weed seedbank back down to manageable levels (Brown and Gallandt, 2017). Others use mulches to prevent late-season weeds from establishing. Black plastic mulch is most common and should be used with as small a planting hole as possible to prevent weeds (usually grasses) from finding their way through (Brown and Gallandt 2018a). Between row zones can also be mulched. If using straw or hay, 9 tons/A is needed to last through the season, but grain can emerge from even "clean" straw (Brown and Gallandt, 2018a) so encouraging pre-sprouting may be helpful.

Rolled rye systems can be effective but need to ensure termination of the rye or yield loss can occur. For example, in Quebec, Miville and Leroux (2018) compared rye terminated with herbicide+roller crimping to roller crimping alone and found that the rye mulch lasted longer and suppressed weeds more effectively when not sprayed, but that pumpkin yield was reduced due to rye "bounce-back." Flail-mowed rye degrades quicker, leaving less than 10% residue covering the soil by early-August (Blomgren 2000).

Living rye mulches are generally too competitive with cucurbits, even if suppressed with low rates of clethodim (Walters and Young, 2008) or hand-weeded in the in-row strip (Grace Marshall, personal communication). But terminated rye can work well in conjunction with plastic mulch. Elderberry Pond Farm in New York will seed rye in the fall and lay plastic mulch over it or only seed between rows if re-using plastic after tomatoes, then terminate the rye with mowing in mid-June and plant cucurbits. Leguminous living mulches, such as the low growing White Dutch Clover in use at Fruition Seeds in New York, can be maintained with mowing between rows of plastic mulched cucurbits to good effect.

Herbicides like ethalfluralin and halosulfuron can control weeds effectively in cucurbits but should not be applied before heavy rains or crop injury can occur (Rapp et al 2004). Therefore, extra care should be taken to ensure the seed slot is refilled with soil properly with the closing wheels (Nathan Johanning, personal communication). If using pre-emergence herbicides in conjunction with rye residue, rate or volume may need to be adjusted (if possible based on the label) to ensure that it reaches the soil. To prevent loss of effectiveness, herbicides should be rotated so that those from the same WSSA group are not used repeatedly. Common groups used in vegatables include Group 1 (i.e. Select, Poast), Group 2 (i.e. Sandea, Matrix), Group 3 (i.e. Curbit, Prowl H2O, Treflan), Group 8 (i.e. Prefar 4-E), Group 9 (i.e. glyphosate), Group 13 (i.e. Command), Group 14 (i.e. Reflex, Aim), and Group 15 (i.e. Dual Magnum, Outlook).

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Herbicide Weed Control Strategies in Orchards

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For the past several years in the Mid-Atlantic tree fruit production areas we have been stressing the importance of staying ahead of orchard weeds by anticipating problems before they occur. One of the major points of attack is the applications of herbicides in the fall postharvest.

Fall applications of herbicides should be part of an overall integrated pest management approach to reduce orchard pests like cat facing insects and rodents. Elimination of winter annual weeds, which are hosts for insects, from the orchard floor reduces cat facing insect populations. Rodents find orchards infested with winter annual weeds attractive. Ground cover provided by weeds creates a desirable rodent habitat.

Additionally, the radiant heat benefit associated with bare soil under trees is often overlooked. Eliminating winter annual weeds allows the soil surface to maximize heat absorption from the sun. During frost events in the spring, heat from the soil is released overnight. The released heat elevates orchard temperatures. The increase in temperature may only be a couple of degrees, however, fruit loss associated with freeze damage can be minimized with small increases in temperature.

Fall herbicides aid spring and summer weed control by delaying spring application time. A fall herbicide spray can delay the spring application for 6 to 8 weeks. The result is a 6 to 8 week extension of the window for pre-emergence weed control into the summer.

There are three common targets with fall applications, annuals, biennials such as wild carrot, and perennial weeds. The winter annual weeds include chickweed, henbit and the mustards. In order to have an effective weed control program you need to distinguish the different types of weeds and when they germinate. **Annuals** are weeds that live less than one year. Annuals are further divided into two classes, summer annuals and winter annuals. 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 one year but less than two full years. Biennials often grow vegetatively during the first year, then flower and die during the second year. Yellow rocket and bull thistle are two common ones in Pennsylvania. **Perennials** are weeds that live longer than two years, often reproducing vegetatively by horizontal shoots, roots, nutlets or rhizomes, as well as by seed.

Most of our herbicides labeled for tree fruit work best when applied before the seedlings emerge or while the weeds are small ($\leq$ 4 inches tall) and are less effective when weed seedlings have become established and have grown beyond the four inch stage.

Growers often overlook the importance of reducing the potential seed bank of weeds. Pigweeds are notorious for producing thousands of seeds from a single plant. These seeds can lay dormant for years in the soil. To reduce the seed bank timely applications of burn down materials, such as paraquat, glufosinate, Treevix, Venue and other materials prevent weeds from producing seeds and is a solid IPM practice to help reduce weed germination and establishment.

For established perennial weeds their eradication is more difficult; therefore, it is best to prevent their seed germination.

Fall application of herbicides is a good means of controlling the winter annuals (WA) and if you include a post-emergent material, burn off any summer annuals that emerged late in the summer. This is also a good time to attack the perennial weeds such as dandelion, thistle and yellow toadflax (also known as butter and eggs).

There are a few steps in making effective fall applications. First, scout your orchards to determine what weeds you have. The Weed Science Society of America (WSSA) has a comprehensive list of university weed identification web pages at http://wssa.net/wssa/weed/weed-identification/weed-id-pages/ . If you are looking for something to carry into the orchard then I would recommend the book Weeds of the Northeast by Uva, Neal and DiTomaso, you can find it on Amazon.com .

Unlike the need for weekly scouting for disease and insects, there are fewer times when you need to scout you weed populations. The first time to check for weeds is early to mid-April. During this time you will see winter annuals that have emerged and any early emerging perennials. The second time to scout would be around June drop in apples. At this time the early season annuals and grasses will have emerged. Finally scout orchards in late August. This timing will tell you what problem weeds escaped your herbicide applications and what weeds may have moved into the orchard. The August scouting will also provide information about weed problems to take care of with fall applications of herbicides

When scouting note if the weeds are predominantly annuals (easier to control), perennials (tougher to control) or a mix of both. Most herbicides have days to harvest limitations if there is still fruit on the tree make sure you comply with those requirements.

If you are primarily after perennial weeds there are two classes of weeds that affect the timing of your treatment. Warm season perennials, such as johnsongrass, pokeweed, hemp dogbane and horsenettle should be treated before frost. The first frost will cause these types of weeds to shut down, if they have not matured and senesced. Herbicides are not effective once these plants have been exposed to frost. On the other hand, winter annuals, biennials and cool season perennials (dandelion, Canada thistle, quackgrass) are most effectively controlled when herbicides are applied mid-October to mid-November. Winter annuals which include chickweed, mustards, groundsel emerge in late summer into fall are still responsive to herbicides albeit at a slower pace. Be aware that treatments that include a residual pre-emergent applied early in the fall when soil temperatures are still warm can result a shorter period of control next spring The earlier timing can reduce the length of control the next spring due to greater herbicide degradation in the early fall. On the plus side fall rains help move the herbicides into the soil and activate the materials.

Good choices of herbicides in the fall include a grass herbicide such as Solicam plus either Chateau or Alion for broadleaves. When we were testing Alion before it was released we had excellent weed control with an application made as late at November 5. Chateau works best when the soil is a little moist so application after a rain shower may give better results. Including glyphosate with either material will eliminate emerged weeds. Sinbar (terbacil) can also work well in the fall (trees must be at least 3 yrs. old) and can control many annual grass and broadleaf weeds. The combination of terbacil with diuron (Karmex) at lower rates (1.0 to 1.5 lb each) controls a wider spectrum than either material alone. Simazine may also be a choice especially for those products that have a 150 pre-harvest interval. As always, be sure to rotate materials between applications to ones with different modes of action. Herbicide modes of action can be

found on-line at a number of different sites using that search terminology. WSSA has a concise mode of action list located at:

http://www.wssa.net/Weeds/Resistance/WSSA-Mechanism-of-Action.pdf

Application of pre-emergent herbicides after tree leaves have dropped may provide less than satisfactory results due to the inability of the herbicide to reach the soil surface through the leaf litter. Pre-emergent materials that work best with no crop or leaf residue include indaziflam, rimsulfuron, and flumioxazin.

Because residual herbicides are applied to the soil and persist for several months, there can be some concerns about movement into ground or surface waters. Some residual herbicides are weakly bound to soil while others are more strongly bound and less likely to leach or move off site. Some mobile pre-emergent materials include simazine, diuron, terbacil, norflurzon and dichlobenil. Non-mobile pre-emergent materials include indaziflam, rimsulfuron, oryzalin, pendimethalin and oxyflurofen. The leachability of the products will also be influenced by the soil type and organic matter content. Soils with higher clay or organic matter will have less problems with movement into ground water.

Apple Fruit Rots…An Increasingly Bitter Experience

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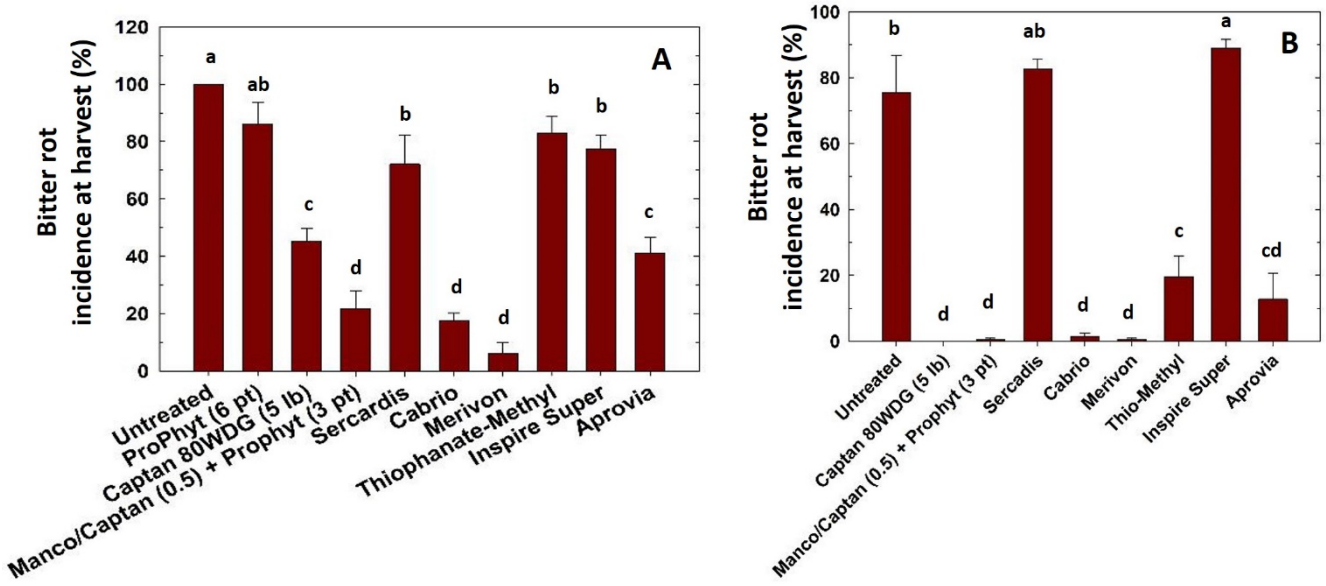
Bitter rot of apple, caused by *Colletotrichum* spp. is arguably the most economically devastating fruit rot of apple in the Eastern United States. Due to the absence of commercially available cultivars with resistance to bitter rot as well as the inconsistency and cost of cultural control measures, fungicides are the industry standard for managing these diseases (Walgenbach et al. 2018). Historically, apple growers in humid apple production regions of the US have relied on 14 to 21 day fungicide application intervals to manage several late season diseases of apple including white rot (*Botryosphaeria dothidea*), black rot (*Botryosphaeria obtusa*), bitter rot (*Colletotrichum* spp.), flyspeck, and sooty blotch (fungal species complexes). Despite regular summer fungicide program to manage these diseases, bitter rot continues to cause significant pre-harvest and post-harvest fruit losses. To develop more consistent management of bitter rot, fungicide trials were conducted in Western North Carolina from 2017-2019 to determine the effects of fungicide application timing, frequency, active ingredient, and spray water pH for the control of bitter rot of apple.

In 2017 and 2018, trials to evaluate the efficacy of non-rotational fungicide programs for the management of apple bitter rot were conducted at the Mountain Horticultural Crops Research and Extension Center in Mills River, NC. The orchard site is a planting of 'Tenroy Gala' trees on M.7 rootstocks planted in 1997. In 2017 and 2018 fungicides were applied on a 10 to 21 day interval, or a 7 to 14 day interval, respectively, dilute to runoff, using a gas powered backpack sprayer (200 PSI) at the following timings: Petal Fall -9th Cover (2017) or Petal Fall-13th Cover (2018). Total precipitation from green tip-harvest was Mar, Apr, May, Jun, Jul and Aug (up to date of harvest on 21 Aug) was 34.0 and 44.3 in., respectively. The incidence of bitter rot at harvest were evaluated was evaluated on 22 Aug 2017 and 21 Aug 2018. The incidence of fruit with early bitter rot symptoms (e.g. fruit spots, but not rotting flesh) and fruit with mature bitter rot symptoms (e.g. macerated flesh under lesion) was expressed as the number of fruit with bitter rot symptoms out of 5 fruit, with 10 collections assessed per 4 replicate trees per treatment. Disease incidence and defoliation data were subjected to analysis of variance (ANOVA) for a randomized block design using accepted statistical procedures and software (i.e. Generalized Linear Mixed Models (GLIMMIX)) procedure of SAS (version 9.4; SAS Institute Inc., Cary, NC).

The non-rotational programs of Captan 80WDG, Captan 80WDG+ ProPhyt, Cabrio EG, and Merivon consistently provided the greatest level of pre-harvest control against bitter rot in 2017 and 2018. While the combination of Captan 80WDG + ProPhyt significantly reduced the incidence of bitter rot in 2017, this trend was not observed in 2018. Merivon is a formulated premixed fungicide containing pyraclostrobin (QoI, FRAC 11, Cabrio EG) and fluxapyroxad (SDHI, FRAC 7, Sercadis). To develop resistance management strategies for Merivon in

populations of *Colletotrichum* spp., Merivon and its active ingredients were evaluated separately in this study. In 2017 and 2018, no significant difference in efficacy were observed between Cabrio EG and Merivon programs. While Sercadis demonstrated little to no reduction in bitter rot incidence compared to the untreated program, incidence data indicates a potential synergistic effect between pyraclostrobin and fluxapyroxad for bitter rot management.



Incidence of mature bitter rot symptoms on 'Tenroy Gala' at harvest in (A) 2017 and (B) 2018.

Advantages of Two Leader Trees

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Multi-leader trees are growing in popularity in orchards around the country. The most common multi-leader set-up is a two leader or bi-axis tree. Most two leader trees are trees that have two buds grafted onto either side of the rootstock. This type of budding is copyrighted by BiBaum®. There are royalties associated with using this grafting style.

There are three main benefits of two leader trees. There is less trees per acre, which means less up-front cost of plant material. Secondly, there is less royalty costs on the trees and rootstocks. Thirdly, in year 3 and later pruning costs will be lower. This is because you can control vigor in the top of the tree and maintain the system better. Lastly, there can be an increase in fruit quality because the system can be trained more as a fruiting wall, which allows sunlight in and better spray coverage. If you are willing to be diligent as to how you are training your newly plant bi-axis trees, it can be a viable way to reach profitability with your new orchard.

With any planting system there are some disadvantages that growers should be aware of. There can be problems with training the newly planted trees in order to get them off to the correct start. It is important to get the leaders to be even in the first few years, because if they start off uneven and are not corrected, they tend to stay uneven. There is also delayed fruit production with bi-axis trees because there is so much energy put into the growth of the tree rather than fruit. Finding the right trees and rootstock choice are also very important. The rootstock has to have enough vigor to grow up two leaders in a reasonable amount of time. There is also the cost of setting up an orchard and trellis system that can handle two leader trees. The nipping, pinching, bending, and trimming that must be in the first three years of the tree's life are crucial to success, but can increase labor costs substantially.

Some other things to think about before diving into a bi-axis orchard are cultivar differences, rootstock compatibility, type of tree, and spacing. When looking at cultivars, points to note are growth habit, tip bearing, or bi-annual tendencies. Rootstocks need to have enough vigor to produce two leaders. Trees from the nursery should be BiBaum® if possible, or whips that can be cut down. Paying for highly feathered trees is not to your benefit, because the trees need to be cut back. Lastly is spacing. The trees should be spaced according to the number of leaders that you plan to have.

Currently at Wafler Nursery we have a dozen or so customers planting multi-leader trees. In our 2020 nursery we are growing 15,000 multi-leader trees. These trees are across the following rootstocks: Geneva® G.11, Geneva® G.935, M26, and B9.

Mechanically Interseeding Cover Crops

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In an attempt to achieve higher organic matter levels and better soil biology, our farm tried for three years to get the traditional No-Till system of rolling & Crimping of dense winter rye crops to work in our organic fields. Unfortunately, we were continuously frustrated by the lack of the Roller/Crimper to adequately kill the winter rye. No matter how many times we rolled the winter rye, it just would not lay down and senesce well enough to apply some traditional No-Till planting procedures. These require planting into a thick weed free matt. If we rolled the rye too early, 30% of the rye would just pop back up or just keep growing; but now sideways! In our last attempt, we tried waiting well into the late pollination stage, only to find, the next week, we had an amazing cover of clover coming up through the matted rye!

At this point, we happened to attend a SARE conference in Pennsylvania about "No-Till Growing in the Northeast" and it was there we saw the 'Interseeder' machine that was developed at Penn State Univ. The three day conference introduced us to the concept of inter-seeding a cover crop into an adolescent cash crop and this seemed like the next best approach to achieving our "No-Till" goals. With this new paradigm, we could increase the active biological surface area of our fields by 72%. Now, we could vastly increase the stable and active carbon biology coming out of late harvested cash crop fields, by having constant living plant material always growing and improving the soils. Ninety percent of the Pennsylvania "No-Till" conference material focused on Grain Corn and Soybeans but we saw the potential for use with our late fall Brassicas.

Wishing Stone Farm is located at the southernmost tip of Rhode Island. We are a peninsula surrounded by the ocean and benefiting from a close proximity to this large body of water. The ocean provides us with a heat sink giving us very late harvest dates for Broccoli, Cabbage, Cauliflower, etc….. However, harvesting Broccoli around the Thanksgiving time frame has the major drawback of being way too late to establish a solid cover crop to protect the fields through the windy winter months. And our southern location doesn't afford us much of any sustained snow cover; so wind/soil erosion can be a big problem as well.

In 2017, we received a CIG grant to bring the 'Interseeder' technology into Rhode Island. For those who might not be familiar with a CIG grant, it is a USDA~NRCS grant awarded to Farmers, Ranchers and Fishermen who bring in new technologies that benefit their respective commodities. The only catch with a CIG grant is one has to commit to a three year schedule of collaborative outreach and public demonstrations of the new technologies affect upon your industry.

The 'Interseeder' is basically a high clearance "No-Till" grain drill with nine drop shoes off set about 9" apart. By taking out drop shoes #3 & #7 one sets up the space to allow a two row cash crop like Broccoli, Corn, Beans that are on cropping centers of 30" to 36". The next decision is estimating what level of adolescent growth you want before inter-seeding your chosen cover

crop mix. Our interseeder has the typical separate seed hoppers to accommodate fine seed like grasses, clovers & mustards, and another hopper to handle winter rye, Hairy vetch, Eco-radish, etc..The large seed hopper has a great ability to seed blended large seed mixes. The only requirement is for the operator to occasionally open the top hopper door and make sure the mixes are not separating from field vibrations and/or seed weight and thickness.

With Brassicas like Broccoli, Cauliflower, Collards, etc., we let them get to the five leaf stage, or about 12" in height before we come through with the Interseeder. For us, this is usually the last cultivation when we often side dress the Col Crops. For Sweet Corn, we let the plants get about 24" or considered at the V~4 to V~6 growth stage. What is critical is to balance getting the cover crops in late enough in the cash crops maturity as to not have the cover crop interfere with the nutrient demands of the cash crop. Another advantage of waiting till the adolescent stage is, that the cash crop is often on the verge of an exponential growth spurt that will effectively shade and slow the maturity of the under sown cover crop. This is especially true of corn. In the YouTube videos below the results of well-timed interseeder cover crops in Grain corn showed no impact on traditional yields. With our Broccoli crop in 2019, we tried multi-species of cover crop blends, ie…Eco-Radish & winter rye and saw only a slight reduction in head size. But that could have been mostly due to setting the seeds per foot too high. In general, we have started too high and are now averaging around 38#s/Ace of a mix of, say Rye and Eco-Radish… Other blends we like are annual rye and Med. Red Clover, or Rye/Vetch, and many others.

Other uses for the Interseeder has been exploiting its "No-Till" soil openers to follow senescing covers with a second cover. Example, we seeded down a Buckwheat crop and just when we would have harrowed it in at the flowering stage; instead, we flail mowed it down and then ran the Interseeder right over the duff and cut in a mix of winter rye and Medium Red Clover. Saving us time money and fuel. Again, drive/spray rows between Broccoli blocks: at seasons end; we flail mow the weeds down and Inter-seed in a mix of Rye/Clover.

In conclusion: the Interseeder has helped us achieve our goals of building organic matter, preventing winter wind erosion and keeping an expansive living mulch growing in our fields eleven months out of the year. It is not a pure "No-Till" play and requires some tillage but the gains biologically are very impressive.

Below video is about a homemade inter seeder:

https://www.youtube.com/watch?v=5ba4BGLsaqw

This video is the Penn State one we got with our grant. $16,500, in 2018.

https://www.youtube.com/watch?v=3vpV9MH7Ak4

Pros, Cons, & Costs of Grass Covers Between Pathways

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INTRODUCTION

Those of us not farming on flat river bottom soils, have slope. With slope comes the potential for soil erosion. Mighty Food farm is on 2-3% slopes, silty-loam soils in Shaftsbury Vermont. We have deep topsoil, some rocks, and erosion potential. We have implemented reduced tillage practices, and various erosion control systems to help keep our soil in place. This presentation is about one of our practices, living pathways between raised plastic beds for long season crops. Mighty Food Farm is a certified organic vegetable farm. We grow 12 acres of mixed veggies annually, and sell to local farmers markets, wholesale, and our year-round CSA. 2020 will mark our 14th year of production. We have a crew of 7 seasonal workers May – October, and 2 full-time crew through the winter months.

PREFACE

This preceding is about our practices of living pathways and how they have helped manage erosion. It will cover the methods we use, the pros, the cons, and the costs. We continue to develop this system to work for certain long season crops on our farm.

CROPS THAT USE THIS SYSTEM

Living pathways have proven to be successful for us on the following crops; strawberries, summer squashes/zucchini, onions, eggplants, brussel sprouts, and our pick your own flowers. There are certainly other crops this method can be used for. We choose long season crops with higher traffic in the aisles.

ONIONS

We have been using the living pathways with onions for 6 years. This season we really feel like we managed the seeding time, mowing, and edge weeding at an “advanced beginner level”. We had 4,000 bed feet of onions in two different blocks. They went in the ground around May 5th and 6th. The best success with the pathways in one block, was waiting three weeks after planting to seed the pathway. Typically, right before we drive the water wheel trans-planter over the row to plant the onions, we will seed the pathways, so the tires packed the seed in. On about 1,000 bed feet, we did not seed prior to planting, got in an early cultivation, briefly touched up the edges of the poly with a stirrup hoe and then seeded the pathway and cultivated it in. These beds had a nicer stand [of rye] and less weed pressure. Seeding rate of about 30 # rye per 225’, 3’pathway. We mowed the onions 6 times, at 1.5 hours per session, for a total of 9 hours of mowing.

LEEKS/BRUSSEL SPROUTS[1]

We used to plant our leeks and Brussels on bare ground. This year we put our entire crops on plastic. We did a Crimson clover and barley mix. The clover was seeds densely, using about 15 pounds for the 6, 200' pathways. We used about 100 pounds of barley per 1,200 feet of pathway (3,100 sq. ft). We mowed about each crop 6 times. 25 minutes per mowing session. The barley tired out around July and then the crimson clover came in very strong, making a dense pathway, and less mowing for the late summer.

We did have galinsoga pressure in spots where the clover was not seeded as dense. In dense clover sections the clover out competed weeds. We go through and hoe the edges to keep them clean of weeds and keep vegetation away from leeks for air circulation.
The mowed pathways make for a nice harvest aisle in the late fall when we bulk harvest our leeks and provide a winter cover after the poly is pulled.

SUMMER SQUASH/ZUCCHINI

Squash aisles get a lot of action from harvesting. We mulched with hay this season, but in the past, we have seeded oats or rye in the pathways and mowed twice to three times during the life cycle of a succession. It makes for a nice harvest aisle for crew, especially in a wet year.
For the earliest panting of squash, like onions, it is best to get a cultivation in prior to seeding down the pathways, when weed pressure is high. Squash is the shortest day crop we use the mowed pathways on. We like it because of the nice foot path for walking and the soil conservation. I do think landscape fabric would prove to be adequate for the aisles in the cucurbit pathways also.

STRAWBERRIES

Our strawberries are raised on plastic beds. We grow 6,000 plants at 2 rows, 12 "; for a total of 3,000 bed feet. We row cover for winter protection using an AG 30 cover. We have managed strawberry pathways a few different ways, trying to find the most cost effective, time saving, and labor-saving method. Still working on it! For living pathways for our strawberries are cultivated all season with and I and J, using sweeps and discs. We stirrup hoe edges. In past years, we seed down oats and clover in early/mid-August. We wanted a good stand of oats about a foot tall to provide a good amount of organic material to cover the pathways. The oats die back, and in the spring, we have a good mulch. We used to much our strawberries, but do not anymore. The winter cover straw provided additional weed control with the winter kill oats for the fruiting year. This year, 2019, our strawberries had a lot of annual weed pressure in the aisles. We were still seeing flushes in August, so we held off on seeding oats and did two more cultivations. In mid-September we seeded the aisles to winter rye and white clover. We are careful not to get seed in the holes where the berries are planted. The rye was about 4 inches tall the first week of November and the clover in the canopy was dense. This field will be row covered for winter protection. In 2020 we will mow the pathways as needed and do a quick hoe on the plastic beds edges (we want a 4-inch swath of bare soil). Hoeing on the edge of the plastic will allow for more air flow for the berries. We used to not hoe the edge but find it's necessary, especially since the edges of the poly are difficult to mow.

[1] It's worth noting, we also tried the mowed pathways on our storage cabbage crop this season, but we cultivated the stand of grass in due to weed pressure in the aisles. We decided it was better to cultivate the weeds than try and manage the moving/mowed pathways. We had erosion issues in the cabbage due to bare ground. It's a catch 22.

COSTS OF MAINTAINING 1 ACRE of MOWED PATHWAYS (90-120-day crop) *
200# Organic Grass seed (rye, barley, oats etc.…) = $125
20# White or crimson clover = $80
Depreciated Mower cost/hour = $2.81 (Initial cost of used mower is $1,200 – life of 10 years)
2 Hours of mowing, every 10-14 days for 70 days = $265.00
Mower cost for hours mowed = $29
Hoeing edges of poly, 2 times, 5 people, @ $15/hour = $150
TOTAL COST = $649

COMPARED TO 1 ACRE STRAW MULCH*
6,000 feet aisles to cover for a 1 acre Raised Bed Plastic Field
300 bales @ $5/bale = $1500
Labor to spread = 5 people for 3 hours @ $15/hr. = $225
Hand weeding hot spots = 5 people, two times, one hour/session @ $15/hr. = $150
TOTAL COST = $1875

COMAPRED TO 1 ACRE CULTIVATED WITH TRACTOR, BARE GROUND*
7 times to cultivated with Kubota M8560, three-point sweeps, finger weeders, discs = $220
Hoeing to touch up edges = 5 people, 1 hour, 3 times @ $15/hour = $225
TOTAL COST = $370[2]

* costs vary will vary with labor, equipment costs, mulch costs, and efficiency.

CONCLUSIONS; MOWING, MULCHING, CULTIVATING
We find the mowed pathways to be helpful for containing soil on erosion pronged ground. We do prefer straw or hay, but the mowed pathways work well and are cost effective. We now make hay on the farm and used second cut bales for mulching, which has proven to be cost effective. It can be difficult to find clean straw or hay without weed seeds, which is why we produce our own. Having more than two acres of mowed pathways may prove to be too much mowing. At most we have 2 acres of pathways, which is manageable with 1 (self-propelled)[3] mower.
One or two cultivations prior to seeding is best to get a clean stand of grass cover. The clover seed is expensive but fills in the pathways nicely when the grass tires out. We highly recommend the clover be densely seeded. Hoeing the edges once or twice, depending on the weed pressure is essential. A swath of bare ground on the edges of the ploy has ensure grasses do not compete with water and nutrient, makes the poly easier to lift post crop, and allows for more air circulation. Our aisles are about 32 inches between poly beds. We make two passes with the mower down each aisle.

It's worth noting that we are also trialing some black fabric in between the rows of plastic beds also. We have not reused the plastic, so we disliked the waste. I think the fabric works best on onions. We have used the mowed pathways with peppers but find the plants to get in the way of mowing, so we prefer a dense mat of hay or straw mulch.

2 Longer season crops, such as strawberries require more cultivation and hoeing, so costs will be higher.
3We have a Billy Goat Mower. It's a great machine, but we have also used a DR mower. Ours was purchased used from a rental place.

Effective and Efficient Interseeding of Cover Crops Between Plastic Mulch for Weed Control and Soil Building

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The bio-plastic poly mulch with a cover cropped pathway system solves several problems, and creates a few new ones! Our primary challenge is taking good care of our limited land base while increasing production efficiency season after season, no matter the weather. We have six acres of tillable land and are grossing $300k with a goal of reaching $500k. With such intensive production, long season cover cropping is hard to fit in, but is exactly what our soil needs. Using tractors for mechanical cultivation would be an obvious way to increase production efficiency, but our high production goals make widely spaced rows impractical.

Our solution is to grow direct seeded crops on permanent raised beds using deep compost, tarps and flame weeding, and most of the transplanted crops on plastic mulch. Integrating cover crops into the poly mulched fields has made a big difference with soil health and creates a nice sod path to harvest crops from. If you have questions or comments about the system described below, please get in touch!

Note: When applying mulch in spring we use .6mil Bio360. When applying in late summer or fall for cropping the following season, we use .8mi Bio360. We use 60" wide mulch but 48" also works.

1. Mow any crop residues or cover crops to lessen potential damage to the poly mulch from long stalks or stems
2. Primary tillage. We use a 7ft spader that covers our wheel tracks.
3. Spread compost (if using) and amendments. We use a smallish manure spreader with a hood over the beaters to concentrate the compost in a narrow band where the mulch will be laid. In fields that don't need compost, we still use the manure spreader to mark out bed spacing. The spreader wheels are eight feet on center, and we want the mulch just a little wider than that, so we offset our spreader wheel tracks so that that the second pass of the wheel is an inch or two from the first.
4. Secondary tillage. We use a six foot roto-tiller set to work about four inches deep to incorporate the compost and prepare a smooth bed, which is so important for good mulch laying. When tilling in between the spreader tracks, I make sure about one foot to either side is not being covered by the tiller hood. This ensures I'm properly centered on the bed.
5. Lay mulch. Since we are going to be mowing the mulch edge, we don't use a raised bed mulch layer. We have had great results with our Rainflo model 345 equipped with twin drip tape spools.

6. Prepare the pathways for cover crop. There will be ridges and ruts left by the covering discs of the mulch layer that need to be smoothed out. We use our BCS 853 walking tractor with a 30" power harrow to smooth them out. Installing a hub extension on the side that will be closest to the mulch allows the harrow to run just to the edge of the mulch.
7. We use a small drop spreader to seed our clover and annual rye grass. It takes two or three passes, but does a good job. For late summer and fall planting, we use fall rye and clover. The fall rye is spread with an Earthway chest spreader.
8. Covering the seed. We use a Two Bad Cats tine weeder to lightly scratch the seeds in. A BCS with a tiller or power harrow attachment also works.
9. Set out transplants! The only unusual thing about planting in this system is that the outer row of plants should be at least six inches in from the edge of the plastic. This makes it easier to mow the weeds and cover crop that grows along the edge of the mulch without damaging your crops.
10. All that's left to do is mow the cover crop every month or so, irrigate regularly (we do a lot of fertigation), and harvest.

Fine Tuning Strawberry Nutrition

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Opening Statement

Many growers believe their strawberry plants receive great benefit from foliar fertilizer application. Cornell Extension has reported that there is marginal benefit when soils are healthy and well prepared before planting. It is a fact that roots absorb and deliver nutrients in the most efficient manner. That being said, I believe 'Fine Tuning' the micronutrients boron and magnesium as a foliar application in the spring is the most underutilized practice. Today's presentation stresses nutrient management planning and application timing. Foliar applications are only recommended during highest demand or if plants show deficiencies.

Complex Dynamics

There is no one size fits all solution to strawberry nutrient management. Every grower has their own unique management practices and favorite strawberry varieties. We will explore the relationship of soil nutrients and the specific needs of the plant. Implementing a detailed nutrient management plan will reduce the need for 'Fine Tuning'. Understanding that most strawberry varieties have their own unique nutritional needs will help develop a nutrition program. I divide strawberry varieties into two categories, the needy and the work horses. I propose you consider treating all your varieties as needy for the best possible outcome.

The Foundation

A strawberry nutrient management plan should follow standard University Extension Guidelines. I believe the Cornell Soil Health Test and management guidelines is one of the best resources available. A soil test for both macro and micro nutrients only provides general recommendations. The combination of soil and tissue tests taken in May of the last growing season provides the clearest picture of the nutrient availability and what you'll need to do before planting strawberries again in that field. Rebuilding the soil after several years of harvest takes 2-3 years or more.

Planting green manure cover crops with specific intent to add organic matter and manage weeds and soil pests is an investment towards a more successful outcome. Cover crops also build a nutrient sink and enhance nutrient availability. This can be further enhanced with No Till practices for several seasons and cover crops with biofumigation properties the summer before planting. An appropriate form of lime to satisfy Magnesium levels should be applied the fall before planting. The end result will be a soil 90% ready before planting.

Planting and Establishment Year

This is where 'Fine Tuning' begins for both macro and micro nutrients. Whether combined or separate applications, there are several considerations. I learned from Mark Bolda with University of California Extension, the strawberry plant nitrogen requirement is only 10-20ppm for the first eight weeks. Almost every cultivated soil meets this requirement. Applying a slow release nitrogen conserves it and provides it when needed. Using a sulfur coated product can provide some of the sulfur component that also feeds microbes. Poultry manure is a popular slower release form. Potassium levels may be higher than needed on some soils at full nitrogen rates. There are several advantages with lower preplant nitrogen levels. Eliminate the potential to burn roots, kill plants and germinate less weeds. Current recommendations are 60-90lbs of actual nitrogen per acre per year. I suggest 20-30lbs actual pre plant slow release and another 20-30lbs actual slow release in early July. A final nitrogen application for the year by September 1st with 20-30lbs actual calcium nitrate or blend. If using drip irrigation, begin in July with two pounds of actual nitrogen per acre per week. Use a blend with micro nutrients and appropriate potassium and phosphate levels according to your soil test. Use calcium nitrate with micros every fourth application. After September 1st, increase the rate to 3lbs actual. Monthly applications of a phosphoric acid product to protect roots during the entire growing season.

Phosphorous levels should be maintained at high to very high levels. Penn State Extension describes phosphorous acting like a micronutrient. A soil test only tells what might be available. While a soil test might show high or very high levels, it could be tied up in organic matter and unavailable. This can be compounded by the fact that roots uptake efficiencies are 20% or less. Compounded again by poor soil health and weak root systems. If you are experiencing phosphorous deficiency symptoms, inspect the root system first. Excellent soil health will produce better root systems that grow towards the available phosphorous. Even at high levels of 50ppm or more some starter may be needed. A maintenance application of 10-20lbs actual in mid to late August to maintain abundance through fall.

Potassium rivals nitrogen as the nutrient absorbed in greatest amount by plants, according to the New England Small Fruit Management Guide. Potassium moves nitrates through the plant and is needed for optimal respiration. Excessively high levels interfere with calcium and magnesium uptake. It is also subject to leaching, spring and fall applications with nitrogen are recommended. Soil type and testing results determine the rate needed for a preplant application. A maintenance application in mid to late August of 20-40lbs actual will be needed.

Strawberry growers pay lots of attention to Calcium and little attention to Sulfur. Sulfur is needed by soil microbes as much as the plant. Keeping both at high levels is important and becomes more difficult in lighter soils. Applying gypsum in mid to late August to maximize sulfur levels, will provide an abundance of calcium for fall and spring.

Boron can be blended into broad cast fertilizers or tank mixed with cover sprays. In most cases, boron becomes toxic when application rates exceed two pounds of actual per acre per year. Adding 1/2lb actual as a foliar application in late August will maintain abundance through spring. While some is absorbed by the leaves, the majority will be in the soil for later.

Other micronutrients include zinc, manganese, copper, iron and molybdenum. In 2007, David Handley discussed how zinc has the potential to be deficient in New England soils. This is always evident in higher pH soils. 'Fine Tuning' all nutrients in late August, requires a soil and foliar sample in early August. The results may indicate necessary adjustments that should be made by September 1st. The goal is abundance during flower bud formation in September.

Spring Applications in Harvest Years

Spring fertilization will not grow significantly bigger berries, the biggest berries are produced from healthy flower buds developed in the fall. Spring fertilizer application recommendations range from zero to 50lbs actual nitrogen per acre. My recommendations range from 15-40lbs actual nitrogen per acre. The perfect field from the fall needs 15-20lbs actual to regrow lost foliage during the winter. The application at or before mulch removal is important to aide cold wet soils. If plants experience winter injury, spoon feeding multiple applications not to exceed 40lbs actual may be needed. Adding 10-20lbs actual phosphorous and 20-40lbs potassium will depend on soil type and fall testing results.

Ammoniated forms of nitrogen can promote anthracnose and should be avoided. Calcium nitrate can extend flower trusses and add to sunscald if applied to close to bloom. Applying calcium nitrate at mulch removal or after first flower is best. I recommend a maximum of 15lbs actual calcium nitrate per acre after full pollination.

'Fine Tuning' before harvest requires soil and foliar samples taken before full bloom, follow recommend procedures. The results may show deficiencies that can be corrected during full bloom. Results can be used with tests taken after renovation to help maximize a nutrient management plan for fall.

Foliar applications of calcium, nitrogen, potassium and phosphorous probably make the grower feel better than the plant. Helping a winter injured plant with 1-2lbs of actual nitrogen per acre per week in cover sprays is an exception. Phosphoric acid foliar products help fungicides work better when used in moderation. Two to three foliar applications of boron and magnesium with cover sprays will help all strawberry varieties, and must be applied to Cabot, Darselect, and Sonata. I recommend alternating 2.5lbs per acre Epsom salts and Solubor. Higher rates can produce phytotoxicity, especially on hot and humid days. I have seen positive results with the use of multi-nutritional foliar fertilizers like Megafol and Growers Mineral solutions. Usually one quart is applied prior to full bloom and again as fruit is sizing. If you're using less than 50 gallons of water per acre cut the rate 25%.

Fertigation rates should never exceed 2-3lbs actual nitrogen in the spring and should always include micronutrients. After full bloom, cut the rate to 1-2lbs actual. Phosphoric acid products should be applied monthly or bi monthly if exceedingly wet. No calcium nitrate two weeks before bloom. Try to limit ammoniated forms as much as possible. Discontinue nitrogen one week before harvest begins, resume as soon as harvest is complete.

Renovation and Fall

Total nitrogen application recommendations after renovation to September range from 40-70lbs actual. I prefer monthly applications of 15-20lbs actual nitrogen to reduce weed germination. A 50/50 blend of calcium nitrate or blend of 20lbs actual nitrogen and 20lbs actual slow release is the exception. The strawberry plant consumes 50-100% more phosphorous and potassium during harvest compared to the rest of the growing season. Add 20-40lbs actual phosphate and 50-70lbs potassium at renovation. In early August take soil and foliar samples to determine final 'Fine Tuning' before September. A final broad cast application by September 1st assures abundance during flower bud formation and to carry the plant into spring.

Special Considerations and Timing

Strawberry varieties with low nitrogen requirement - Malwina, Sonata need 25-50% less.

Strawberry varieties with high nitrogen requirement - Chandler, Albion, San Andreas need 25-50%more.

Cabot needs extra boron before and after bloom to reduce splitting. Extra water after bloom is also helpful.

Darselect and Sonata need extra Magnesium in April, May, and August.

All strawberry varieties will benefit with some foliar boron and magnesium before and after bloom.

Soil and tissue test by August every year, and before bloom of second year and beyond.

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Managing Wireworms in Root Crops

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Wireworms are an increasing problem in root crop vegetable production. Some of this increase can be attributed to the adoption of grass-based cover crop and small grain rotations for soil building. The adult stage of the wireworm, known as click beetles, prefers grassy fields for egg laying June through August. Growers with grassy fields during this period have seen high levels of wireworm damage in subsequent years when susceptible crops are grown. Wireworms have a large host range that includes seeds of bean and corn, various root crops such as sweet potato, carrots, beets, and bulbing crops like garlic. Damage to crops may be evident for several years after a field is taken out of a grass-based cover crop, as it can take up to five years for the wireworm to complete its lifecycle in the soil and emerge as an adult click beetle.

In conventional vegetable production there are a few insecticides that can be applied prior to, or at planting, on select vegetable crops to reduce wireworm damage. In organic production however, growers must rely on cultural tactics to reduced damage. The lack of any "rescue" options in organic production spurred the investigation of entomopathogenic nematodes (EPNs) as a potential biocontrol agent in the suppression of wireworm infestations. Dr. Elson Shields and Tony Testa from the Cornell University Dept. of Entomology have isolated a complex of New York native EPNs that inhabit shallow and deep profiles of the soil, are cold tolerant, persist in the soil for years and have proven successful for limiting other highly-destructive insects. In 2017, Eastern NY Commercial Horticulture Program vegetable production specialists began a research and demonstration project with Shields and Testa to determine if EPNs are a viable biocontrol agent for wireworm management. Results from trials at multiple farm locations in Eastern NY growing sweet potatoes have shown significant reduction (36%, 80%) in wireworm damage in EPN treated plots when compared to untreated plots.

One of the most practical ways to manage wireworms is to keep grasses out of fields, particularly June through August. However, this tactic does not necessarily work with growers' soil health or crop rotation goals. Treating soils with EPNs can provide a reasonable level of wireworm suppression and can be combined with cultural and chemical control strategies to produce marketable root crops in fields with known wireworm pressure.

Beating Common Beet Issues

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Germination problems, hollow heart, and Cercospora leaf spot are common issues that growers face in beet production. Review of the problems and some recommendations of production practices to minimize these issues will be made, as well as provide tips for maintaining beet quality during storage

Germination issues:
Do germination testing pre-season to determine how good your seed is. Seed a 72 or 98 cell flat and figure out the germination percentage. See if it matches what seed package specifies.

Soil that is too cool and wet or too warm and dry will decrease germination rates. Avoid seeding if weather is predicted to be in these categories. Use row cover on hoops to help protect against too cool conditions. Have irrigation set up to keep moist if warm, dry, and windy. Avoid cool soils with heavier organic matter (prefer well-rotted material).

Addition of a seed treatment with a soil inoculum (Trichoderma sps. for example) or adding directly to soil has shown some promise with improved germination and seedling stand.

Hollow heart
Several factors influence this root problem
Most commonly, deficiency in boron 1-2lbs/A needed if soil test comes back low to medium
Moisture stress – which interferes with the uptake of nutrients. Critical times are during germination through seedling establishment and during root enlargement. Keeping the root zone moist in that 3-3.5" depth important. ¼"/day early then ¼"-1/3" day during root enlargement on average. Better to have more frequent irrigations of lesser amounts than heavy irrigation once a week.

Leaf Disease–Cercospora leaf spot. This disease shows up later in the season under warmer temperatures above 75F and high humidity especially under rainy conditions. Spots early in the season is bacterial leaf spot. Appears first as small circular lesions grayish in color with distinct dark brown (on yellow beet varieties) to purplish/red (on red varieties) halos. Often tiny black specks can be seen in the spots (fungal spores). Another leaf disease, Phoma, has spots of various sizes with concentric ring patterns.

There are no current resistant varieties though Ruby Queen is somewhat more tolerant than others. There should be a minimum of 3 years rotation for beets and chard. Grains and alliums are good rotation crops.

Poor air circulation can help reduce spread of the disease by allowing for prolonged leaf wetness. Avoid planting near tree lines, hedgerows, or hilly ground where air movement is low. Keep

weeds under control (some weeds are hosts as well). Wider spacing of beet plants and more effective thinning can also help with reducing spread through allowing more air flow.

The biopesticide, Bacillus amyloliquefaciens strain D747 (DoubleNickel) has shown effectiveness in NY trials. Copper mixed with a spray oil can also be used but read label instructions for more details (REI varies).

Storage Considerations

To maintain good quality in storage, there are a number of factors to take into consideration. Post-harvest handling is important and this starts in the field before harvest. Weed management and cultivation can affect storage. Keeping ahead of the weeds by taking them out when they are small will help avoid damage to the beet root. Trying to go back a rescue a field of beets when the weeds are tall and the beet roots are large will only lead to nicking or scratching the root. The injury can allow for rot to occur once in storage.

Cultivation is important for weed control. One important thing to remember is that if soil is thrown up onto the beet plants where the crown is a bit sunken, this opens up for a chance of crown rot or pocket rot (Rhizoctonia). Late in the season try to keep the soil from burying the crown.

Storage quality can be affected by overly aggressive handling during harvest. Any sort of injury to the root can open up a wound for storage rot to take hold. Use harvest bins that don't have rough surfaces or corners. Caution should be taken during digging out of roots. Dumping from harvest bins into other containers should be done to minimize damage to the skin of the roots.

Storage conditions are important. Cooler temperature needs to be close to 32F. How well do you trust your cooler? Relative humidity 98% (ideally) which can be achieved through tighter packaging yet allows for air flow to reduce condensation (waxed cartons with air holes or perforated plastic bags). Fans in the cooler are good for moving air around. It is also important that coolers have a total air exchange. This removes CO2 and ethylene from the air that can negatively affect shelf life. Improper cooler temperature and humidity can account for losses of crop that could have been easily avoided.

Avoid washing beets before putting into the cooler. Removing soil can cause abrasions which are open wounds for storage rots. If there is heavy mud stuck on the roots, rinsing may be needed but care must be taken not scrape the roots. When sales day arrives, take out the roots you need for the day and wash.

New Root Crop Varieties for Improved Pest Management

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One of the goals of plant breeders and vegetable seed companies is to develop varieties with better pest and disease resistance, along with improved horticultural and quality characteristics. In this presentation we will look at some of the common diseases and disorders that affect production of some root crops, and review some of the newest varieties with improved tolerances.

Our free app, CROPALYSER, is a handy tool to help you diagnose vegetable diseases in the field, with the help of nice pictures of symptoms and descriptions of disease development and suggestion for management.

BEETS – Cercospora Leaf Spot

Cercospora Leaf Spot is a common disease of table beets. Cercospora forms characteristics lesions on the leaves, and heavy infection can cause the leaves to die. This, in turn, can have serious impact on yield and quality of the beets.

BEJO is actively breeding for tolerance to Cercospora, and several new varieties have been introduced:

BORO this variety has performed well for several years. The leaves have fairly good tolerance to Cercospora and the tops are nicely erect. The roots have nice quality and are sweet. BORO is also available as organic seed.

BOHAN originally developed for the wet season in Brazil, BOHAN also works very well in our area. BOHAN has a well-developed tap root that stands up to wet and compacted soils. The tops are tall and very strong, and the beets are easily accepted by consumers.

BRESKO this new variety has improved resistance to Cercospora, but also offers very high quality beets with a smooth skin and nicely round shape. The medium tops are healthy and have good cold tolerance.

BEETS – Rhizomania

Rhizomania is a disease of beets that is caused by a virus, which in turn is transmitted by a soil-borne fungus (Polymyxa betae). The fungus is quite common in our soils, but the fungus itself does not cause problems in beets.

Beets that are infected with the Rhizomania virus are badly stunted, with the tap root having many side roots and a "bearded" appearance.

Rhizomania has become rather widespread in Europe and is now also showing up in some beet production areas in the USA and Canada. Fortunately, tolerant varieties are available. Keep an eye on your beets – switch to resistant varieties when Rhizomania is confirmed on your farm.

MANZU mid-season beet. Similar to RED ACE.
PALAU mid-season beet. Nicely round, smooth skin.

ONIONS – Downy Mildew

There are many different fungal diseases of onions and shallots, and most of them can be managed without much crop loss. Downy Mildew, however, can be very aggressive and can completely wipe out the crop in 7 – 10 days. Downy Mildew can be particularly devastating in organic production systems.

Our onion varieties with resistance to Downy Mildew are:

YANKEE 110 days. Nice yellow storage onion, medium yield potential.
POWELL 107 days. Higher yield potential than YANKEE. Strong tops, round bulbs, long storage.

There is also resistance to Downy Mildew in shallots:

BGS-124 INNOVATOR true-seeded shallot (produce from seed or transplants). Good yield potential. Tear drop shape. Pink flesh. Long storage.

CARROTS – healthy tops.

The complex of foliar diseases (Alternaria, Septoria, Bacterial Blight) can reduce the visual appeal of the tops of bunching carrots. In addition, some varieties have weak top attachment, and often have yellow leaves (not diseased) that give the freshly bunched carrots an "old" appearance.

Our variety, MOKUM, has long been the standard for flavor in early bunching carrots, but new varieties have tops with better health and strength while still having excellent texture and flavor.

MOKUM the standard for flavor, but weak tops
ADANA excellent flavor. Stronger and taller tops have better cold tolerance. Slightly longer roots than MOKUM, more uniform, better field holding. Good for fall production.
ARANKA similar tops as MOKUM, but stronger attachment. Good resistance to yellowing. Better and earlier fill than MOKUM.

PARSNIP – Canker, Ginger Spot

We distribute seed of Parsnips from our breeding partner in England, ELSOM Seeds. These varieties have much improved resistance to "canker", which can be caused by a variety of soil-borne fungi. "Canker" is a catch-all name that is used to describe a variety of rots and discolorations, either caused by bacteria or fungi. Older varieties tend to have heavy shoulders and a long, thin tail. These types of roots are easily damaged during harvest and loading, with bruising of the shoulders. These bruised shoulders often break down in storage.
The newer varieties have better tip fill, and relatively more slender shoulders, and therefore do not bruise as easily.

Varieties with good resistance to Canker are:

PANORAMA late season, nice cello's, long storage.
PEARL late season, cello's, nice white color. Very long storage.

RUTABAGA – hollow heart, black heart

Several types of Brassicas can have issues with hollow stem (broccoli), hollow core (cauliflower) or hollow heart (Rutabaga), and often the growers are advised to use more Boron to prevent these disorders. But, often these disorders are just caused by uneven growth (no growth during stressful periods, followed by very rapid growth when the stress is relieved,) Internal tissues often cannot keep up with the rapid growth on the perimeter of the stem/curd/crown/bulb, and leaves a hollow core.
Use moderate fertility and choose varieties with good stress tolerance to avoid problems with hollow heart.

Our partners at ELSOM have developed these new hybrid varieties of Rutabaga (ask us for trial seed!):

SW 42 elongated globe shape, average vigor, very good overall
SW 43 elongated globe shaped, very vigorous, excellent quality

FENNEL – bolting

Fennel is sensitive to day length, and growers in the Northeast should work with intermediate day varieties. In addition, fennel will bolt easily when planted in early summer when days continue to grow longer. For this reason, it is a good idea to plant most fennel varieties after the longest day and transplants in the first week of July.

New varieties with much improved resistance to bolting include:

ANTARES very early maturity. Excellent bolting resistance. For spring and summer production.
DRAGON early maturity. Very high resistance to bolting. Fits well in the most difficult growing conditions in summer. Strong skin – long shelf life.
ORAZIO mid-season. Nice shape. For summer and fall production.

Growing Ginger in Tunnels

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We have been growing ginger and turmeric in the Hudson Valley since 2012. This presentation will cover how we start and manage our crop of ginger from start to finish, a time frame covering roughly 8 months.

We purchase our ginger from Hawaii Clean Seed (also known as Biker Dude Puna Organics). We retail at $20.00/lb and wholesale at about $12-$14/lb. We start our ginger in the beginning of March, in 1020 trays of potting soil. We use Vermont compost, Forte V. The ginger is in those trays for approximately 2.5 months before being transplanted out. We germinate them on heated benches in a heated greenhouse. Sprouting happens over a period of 2.5 months. We aim to plant the ginger out in our high tunnels around the 3rd week in May, after the chance of cold weather is largely past.

We use 30" wide raised beds and plant in a single row at 6" spacing. We dig a channel down the middle of the bed, which naturally forms a hill on either side of the planting area. We then tease the young ginger plants apart since their roots are somewhat tangled with each other and plant them out. After getting them all set up in the channel we apply some compost on top of the ginger rhizome before covering with soil. Ginger is a heavy feeder and likes a lot of organic matter. Our tunnels are between 8-10% organic matter. We then cover and slightly hill the plant at the time of placing the rhizome in the soil.

Throughout the season we make sure the ginger gets regular watering, similar to our tomatoes since they are on the same irrigation set up. We give the ginger a sprinkling of Neptune's Fish Emulsion mixture, 2-3 times during the growing season for a little boost. We have added more irrigation lines to keep the ginger bed well-watered. We did experiment with some overhead irrigation this year, it did not work well.

We start to harvest for Labor Day Market and continue to harvest for market and wholesale until mid-October. The ginger really starts to size up in the month of September and by the beginning of October the hands of ginger are quite large. When you start to see the flower buds being produced on the plant it is a nice indication that the ginger root is now starting to gain some weight. There is a good bit of difference in size between the ginger that we harvest in the beginning of September and the ginger we harvest in mid-October.

Turmeric is widely known for its anti-inflammatory attributes. Turmeric takes a little longer to get going and definitely benefits from the extra growing time in September and October. It is possible to get some very large hands of turmeric as well. Different varieties grow at different rates. We have found the yellow to be the most aggressive and the strongest in flavor. Ginger-turmeric elixirs have become a favorite fall drink. Harvesting a sizable crop of these tropical plants in the Northeast is quite exciting. Both ginger and turmeric can add some real exotic appeal to your market or CSA offerings in early fall.

Medicine Plants: Companions & Partners for Vegetables & Fruits
& The Farmers Who Grow Them

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This talk hopes to inspire growers to learn, embrace and promote the nutritional, healing benefits of the foods you grow and further, to expand your considerations to include medicinal herbs, in ways that will

1. Save you time and pain
2. Benefit your soil health
3. Protect and invigorate your primary crops
4. Broaden your market presence
5. Increase profits
6. Potentially help you to be healthier for longer
7. Be an active participant in the healing of our planet

Growing medicine plants might actually help assure that you can do the work of your heart and soul productively for as long as you want!

Care for the soil by keeping it covered, cool and moist and use everything; build soil by continually returning composted plant materials to beds and rotating crops where possible. The resulting healthy soil assures heartier plants, bountiful harvests of more nutrient-dense foods, and less waste.

Medicinal plants as a soil cover protect soil aggregate stability and conserve water by way of underground mycelium, highly beneficial to the crop. The two-fold added bonus for the farmer is less time weeding and a popular secondary crop!

German Chamomile – *matricaria chamomilla* – known as "the plants' physician" can be beneficial to most fruits, veggies and berries. It attracts pollinators as well as beneficial insects that help control aphids and mites, especially with brassicas and fruit trees. At market, customers will be excited to buy fresh flowers for tea! At season's end, chamomile will drop seeds and new plants will emerge in spring and are easily transplanted throughout the garden. Scatter some in hay fields for added health benefits to animals.

Purselane – *Portulaca oleracea* – has most often been considered an annoying weed in the garden until recent years. It's a champion soil cover with cabbage, lettuces, beets, turnips, radishes and carrots. It keeps the soil cool, prevents weeds and moves over for the taller plants to rise and gather the sun. As a tasty and succulent salad veggie, purselane is rich in Vitamins A, C,

B2 (headaches, migraines), iron, calcium, manganese and magnesium to support bone strength, omega 3 fatty acids to promote heart health, and is showing great research results as a treatment for breast cancer.

Chickweed – *Stellaria media* – is a lovely, delicious and hearty plant that not only is a great soil cover and weed deterrent, but also improves phosphorus and potassium levels in the soil. Pollinators enjoy the nectar of the tiny white flowers. As an addition to your salad greens market, this is a great secondary market crop. Include nutrition signage to draw customer interest: May support healthy metabolism, improves nutrient absorption, rich in vitamins A, D, B Complex, C; loaded with calcium, potassium, phosphorus, zinc, manganese, sodium, copper, iron and silica! Chickweed is nature's multivitamin in your salad bowl and soup pot!

Vegetable Medicine:
Tomatoes – are rich in lutein and vitamin C. Lutein has been proven beneficial for protection of the prostate gland, eye health and a preventive against diabetes, cardiovascular disease, cataracts and many cancers.

Dill –This favorite among cooks and pickle makers will expand your customer base while protecting your tomatoes from hornworm, improving flavor and boosting growth! Also a great dog treat – they love it like cats love catnip.

Basil – Repels thrips and aphids and is a natural fungicide. Delicious in its own right, grown as a companion to tomatoes, it improves the fruit's flavor. Your market customers will love pictures of Caprese salad and your profits will show it! Basil improves digestion with its warming, aromatic properties

Calendula – Tonic to the garden! Gathers nutrients into soil. Loves chard, radish, carrots, and tomatoes. Calendula moves stagnant lymph, breaks up stubborn mucus and is great for our skin. Use in creams, lotions & tea. Cream is specific for post-mastectomy healing. Al this and it's a gorgeous cut flower!

Beans – Good source of plant protein, but hard to digest. complex carbs and fiber, beans contain a powerhouse of nutrients including antioxidants, vitamins and minerals including copper, folate, iron, magnesium, manganese, phosphorous, potassium and zinc. In the garden, this legume fixes soil nitrogen. Consider these five companions:

French Marigold – Repels Mexican Bean Beetle.

Catnip – Repels Flea Beetle. As an herbal tea, this mint family plant is a tasty digestive bitter and will ease the pangs of colic in babies, adults and pets. Pair with that carminative chamomile that's all over your garden and sell as an after-meal digestive tea! The fresh herbs will keep in the fridge for a week, then the customer comes back for more! Oh, and of course anyone with a kitty will be very excited to bring them a special catnip treat.

Cilantro – Attracts beneficial tachinid flies, parasitic wasps, repels aphids, potato beetles and spider mites. People have developed a taste for this herb since Mexican and Indian foods have become popular, and now we love it. Market it as a salad green, condiment for chili and other bean dishes, and of course, as a medicine plant. In a tea or bath it leaches heavy metals mercury,

lead and aluminum from the body, something many folks are also very interested in. Cilantro is also highly antioxidant making it useful in immune support and cancer prevention/treatment. Grow a lot and let it go to seed – the seed is coriander, rich in its own health benefits against hypertension and urinary issues. Two market additions in one plant!

Rosemary – Adored by cooks and herbalists of all time! In the garden, rosemary repels many beetles and flies, as do so many of the highly aromatic herbs. Whether wrapped in a lamb roast, added to soups or vegetable dishes or drunk as a tea, rosemary is delicious and uplifting to the spirit. Always a hit at market…..not offered by many growers, because it must be potted before frost and kept above 20^{o} in relatively bright light throughout the winter. Sounds like a lot of work, but once you've fallen in love with Rosemary, it will be a relationship worthy of nurturing.

Speaking of Berries!

Everybody loves their berries, as they should! The nutritional and healing benefits of strawberries and blueberries are too numerous to talk about in this very short lecture.

There are 721 known biological activities in strawberries!

- Rich in Vitamin C, their antioxidant qualities support immune and skin health.
- The trace mineral manganese is necessary to normal brain and nervous system function.
- Folate (B9) facilitates normal tissue growth and cell function, particularly important during pregnancy and aging.
- Potassium supports electrolyte balance and blood pressure regulation.

Also antioxidant, strawberries can reduce risk of disease, reduce inflammation, help regulate blood glucose and reduce incidences of epileptic seizures. For people who do not eat grain, strawberries are a good manganese replacement source.

Phytochemical properties and antioxidant activities of blueberries make them a daily recommendation in the American diet. They have one of the highest antioxidant levels of all fruits and veggies (coming from flavonoids), reducing DNA damage caused by oxidation, the primary cause of macular degeneration, aging and cancer.

They bring us fiber, Vitamins C and K and manganese. Studies show that eating blueberries may improve thinking and memory skills in older adults with mild cognitive impairment.

Not only are the berries of these fruits delicious and beneficial to our health; so are their leaves! They are astringent (toning, tightening) to all body systems, thereby improving digestive and urinary function and improving vision issues, particularly night blindness.

While blueberries and strawberries do quite nicely on their own with good pine needle mulch, basil, borage and thyme will be good companions to them as well as to all fruit trees, and always welcome at market.

A Few More Good Companion Plants

- Asparagus, Tomato, Parsley, Basil
- Beets, Onions, Kohlrabi, Lettuces, Cabbage
- Brassicas, Hyssop, Thyme, Potatoes, Celery, Dill, Chamomile, Sage
- Corn & Sunflowers, pumpkin, squashes

- Potatoes, beans, corn, cabbage, horseradish

Good For Us – Not For Each Other!

While there are good companions in the garden, there are also plants that don't do well together……just like people! Here are a few examples of plants to avoid growing together:

- Basil and Rue – Separate by at least 30 feet. Neither will do well closer.
- Fennel – Needs to be totally separate from other plants; it will inhibit all.
- Tomatoes and Corn – Hornworms and corn borers are similar and will be more problematic. Separate by 50 feet.
- Brassicas and Radishes – Radishes attract flea beetle. Separate by 50 feet.
- Beans – Onions, garlic, gladiolus, fennel. Separate by 25 feet
- Beets – Pole beans, mustards. Separate by 20-30 feet.
- Potatoes – Melons, pumpkin, squash, cucumber, tomato, raspberry. Separate by at least 30 feet from farthest vining reach.

See a more complete chart at permaculturenews.org.

The importance of organic food production cannot be overstated. Non-organic crops can contain residues of toxic chemicals high enough to cross the blood-brain barrier. Population-based studies have revealed possible relations between the exposure to such chemicals and serious health effects:

- Cardiovascular disease
- Amino acid deficiency
- Gluten intolerance
    - Associated with deficiencies in essential trace metals
- Endocrine disruption
    - Diabetes
    - Negative effects on male reproductive system
    - DNA damages in human sperm
    - Miscarriage
    - Infertility
    - Sexual maturation delays
    - General concerns for human reproductive health
    - Reproductive cancers
- Hypertension
- Negative effects on nervous system
- Dementia
- Increased risk for non-Hodgkin's Lymphoma
- Pediatric neurological issues

Many of these listed might also apply to livestock. Dangers to the future of the bee populations is critical and well known. But there is hope for us, yet. It's all up to us and the choices we make.

Saffron: The Next Best Thing for Crop Diversification

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Over 95% of Northeastern farms are ranked "small" by USDA, grossing less than $350,000 annually.[1] Crop diversification is key to their viability. **SAFFRON**—the stigmas of a fall-blooming crocus, and the world's most expensive spice (over $5,000/lb)—could strengthen the economic security of small farms (Fig. 1). Since 2015, over 2,000 growers, most Northeasterners, expressed interest in saffron production, and 75% are growing it now or will in 2020. The global saffron market is valued at $646 million and US market revenue from imported product was estimated at over $60 million in 2018, demonstrating the potential demand for locally-grown saffron.[2] It is commonly used as a culinary spice in ethnic cuisines, but also is reported to have medicinal properties, increasing its value above other herbs and spices. In 2016, the US was the 3rd largest saffron importer, bringing in over 37 tons (worth $55 million). University of Vermont researchers have shown that saffron can be grown successfully in the field and in high tunnels in the colder regions of the Northeast (Fig. 2). The potential to supply US markets with locally-produced saffron could strengthen economic security for small diversified nationwide farmers. Corms remain in the ground for 3-6 years, increasing in density and saffron yield annually. Though labor costs to pick/process saffron are high, they are not more than for high-tunnel tomatoes, a widespread Northeastern crop. Mechanical saffron harvesting/processing equipment is under development to reduce labor expenses and luckily saffron harvesting occurs for 2-4 weeks in October-November when field work demands are less. The USDA doesn't collect data on saffron production but one major supplier sold >200,000 corms to US growers (new and established growers) in 2019, equivalent to over one acre of new saffron production. In a 2019 survey of 550 Saffronnet subscribers, 75% intend to harvest saffron in 2019 and 90% by 2020.

Fig. 1. Saffron flower showing red stigmas, yellow anthers and purple petals.

Fig. 2. High tunnel and field production of saffron in Vermont. Left: Brian Leven, Stowe, VT, grows it in raised beds in high tunnels (Photo by G. Miller, Stowe Today); Patti and John Padua, Monkton, VT, grow it in the field.

Though saffron is suitable for a wide range of growers, the most likely ones are

vegetable farmers and nursery/floriculture producers. It is an emerging crop, and US growers report selling their product for between $20-75 per gram (equivalent to $9,000-34,000/lb). In a good year, a grower should be able to harvest around 5-12 lb/acre, within 3 years of establishing their saffron beds. Skeptics question the marketability of saffron, but given the strong locovore movement, US saffron could compete for a share of this market. To develop a viable market for saffron, it is essential that growers have enough high-quality product to satisfy the demand. The first step is to refine production methods to maximize on yield. We have been working at the Univ. of Vermont since 2015 on several aspects of saffron production. Due to concerns that saffron might not survive the cold winter temperatures in Vermont we initially focused on growing it in high tunnels. Because many growers use their high tunnels for tomatoes, we developed a system of growing saffron in milk crates which could be moved out in the spring (Fig. 3). This would allow growers to maximize on their tunnel space with two high value crops. Our results over two years showed that saffron yields were greater in crates than in ground (in raised beds) and yield increased in the second year (Fig. 4). Rodent damage was a major pest issue for the in-ground plantings.

Fig. 3. Saffron grown in milk crates in a high tunnel.

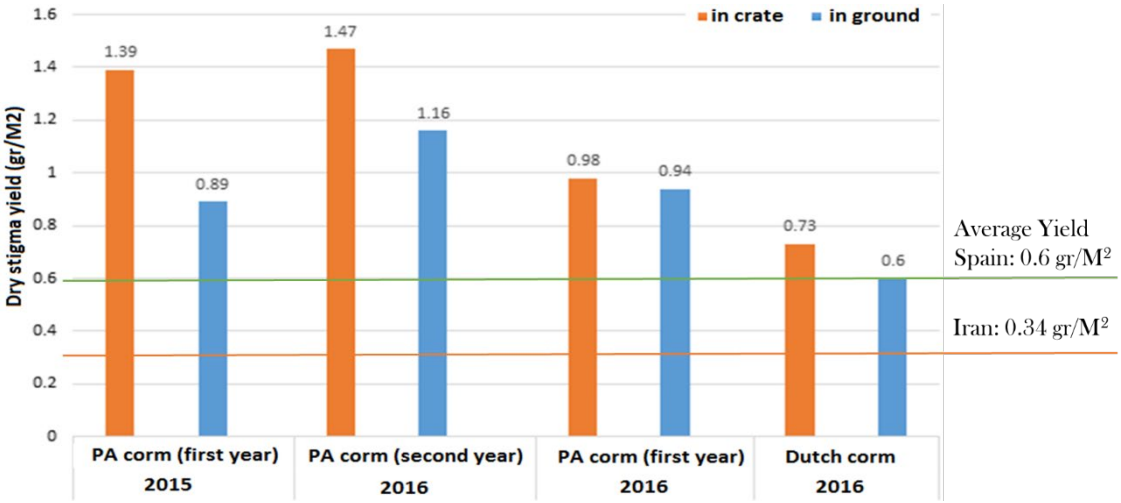

Fig. 4. Saffron yield when grown in crates or in raised beds over 2 years (right).

The key to cost-effective saffron cultivation is to promote secondary corm production. We found that the number of corms almost doubled from Year 1 to 2 in the crate treatment (Table 1). The number of corms declined in Year 2 for the in-ground treatment as a result of rodent feeding.

Table 1. Corm production in ground and in crates

Treatment	# Primary corms 2015	# Secondary corms 2016	Average Wt/corm 2015 (gr)	Average wt/corm 2016 (gr)
In ground	465	407	11.2	10.3
In crates	465	756	11.2	7.7

Note: We have since observed 3 or more corms developing from a single corm 1 year after planting in the field.

Because some growers prefer to grow in the field rather than in high tunnels, we are finishing up a 2-year study to assess the suitability of growing saffron outside in different coldhardiness zones in Vermont (Zone 4a, 4b, and 5a). We have found that saffron thrives in these three zones. The greatest issues growers have faced are weed control, rodent damage and poorly-drained soil. Because saffron corms stay in the same growing bed for 4-6 years, it is essential that weeds are eliminated before the corms are planted. We experimented with covering the saffron beds with weed cloth over the summer and that reduced weed pressure (Fig. 5). It is important to remove the weed cloth in August before the saffron begins to sprout. This may not be suitable for areas where summer temperatures are particularly high.

Fig. 5. VT saffron beds covered over the summer with weed cloth, and uncovered in August.

Fig. 6. Preparation of a saffron beds with crushed oyster shells.

Several strategies for minimizing rodent feeding on the corms are being tested, including spreading crushed oyster shells (Fig. 6). We learned first hand that planting saffron in heavy clay soils that are poorly drained can be a problem. Water-logged soil in the spring can lead to corm rot and infestations of bulb mites.

There is much to be learned to refine and perfect saffron production in the diverse conditions found in Northeast and across the US. Every year more growers are trying saffron for the first time. These innovative producers will lead the way for this emerging industry, which will hopefully result in enhanced revenues for diversified growers of all types.

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To subscribe to *Saffronnet*, our saffron email list, contact Margaret Skinner at mskinner@uvm.edu

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Growing Globe Artichokes and Belgian Endive in Connecticut

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The globe artichoke (*Cynara scolymus*) is a member of the Composite family that is closely related to the thistle. The edible portion is the immature flower bud. The buds or "globes" are composed of fleshy flower bracts and the receptacle (heart) to which the bracts are attached. When grown from seed, the artichoke plant is a biennial, growing vegetatively the first year and producing edible flower buds the second year. This two-year cycle requires frost-free winters for survival. In Connecticut, survival of artichoke plants during harsh winters is virtually impossible. The growth cycle, however, can be shortened by vernalization (cool, moist treatment) of germinating seed or growing plants. This treatment initiates flower budding in five to six-month-old plants and permit production of artichokes in a single year. Thus, the globe artichoke may be grown as an annual plant in New England.

Cultivars. Four artichoke cultivars are available that can be grown from seed. Imperial Star and Colorado Star are cultivars designed for annual culture from seed and feature low vernalization requirements to trigger bud formation (estimated to be less than 250 cumulative hours below 50°F). The buds of Imperial Star are thornless, glossy, and grayish-green in color while Colorado Star are purplish in color. Green Globe and Green Globe Improved are the standard cultivars used commercially in California and require at least 500 hours of temperatures below 50°F for vernalization. Both are reliable cultivars, but some buds are thorny.

Vernalization. Vernalization is the metabolic process that causes a plant to change from a vegetative stage to a reproductive stage. This change may be initiated by subjecting the germinating seed or growing plant to a cool, moist treatment. There are two different levels of cold treatments, "induced" and "natural". Either method can be used, but "induced" treatments are more effective for Green Globe and Green Globe Improved.

Induced vernalization is usually initiated in the first week of February. After soaking seeds in tap water at room temperature for two days to soften the seed coat, seeds are packed in moist unshredded sphagnum moss in an unsealed one-gallon plastic bag and refrigerated for four weeks at 36-40°F. The bags are examined weekly and moistened if necessary. In early March, four-week-old germinated seed with roots extending ¼ to ¾ inch are then transferred to one-quart containers and placed in a greenhouse, under grow lights, or in a sunny window. The media that we used was Promix BX.

"Natural" vernalization is begun in the first week of March. As before, presoaked seeds are placed in an unsealed one-gallon plastic bag filled with moist unshredded sphagnum moss, but left at room temperature (65-70°F). After about ten days, germinated seeds are planted in one quart containers as before. In early April, the containers are transferred to a cold frame for early growth and vernalization until they are ready for transplanting at the four-leaf stage.

Fertilization. Soluble 20-20-20 fertilizer (1 tbsp/gal) is added to the potted seedlings about ten days before transplanting. The field soil is fertilized with 10-10-10 at a rate of 1300 lb/A before transplanting. The pH of the soil should be about 6.5.

Field Transplanting. Seedlings in the four-leaf stage are transferred to an outdoor cold frame for hardening before transplanting in the field. Seedlings are covered at night only on the threat of frost. In our trials, uncovered seedlings were inadvertently subjected to night temperatures as low as 29ºF without apparent injury.

Seedlings are transplanted into the field in early to mid-May. Transplants are spaced two-feet apart in rows four-feet apart. Most container-grown transplants will have a prominent tap root curled at the bottom of each pot. When transplanting, after the root ball is removed from the pot, the tap root should be manually straightened, and the plant set in a hole deep enough to accommodate the length of the tap root. Usually, transplanted artichokes display very slow early growth. It is common for plants to sit ten to fourteen days with little noticeable growth.

Mulching. Summer heat (80-90ºF) may cause devernalization of unprotected plants. Immediately after transplanting, the soil can be mulched with four inches of an organic mulch (undecomposed leaves, grass clippings, straw) to cool the soil. Although it is necessary to mulch only within twelve inches of the plant to prevent devernalization, the remaining space between the rows can be mulched to control weeds.

Gibberellic acid treatment. Gibberellic acid (GA3) is a natural plant hormone produced by most herbaceous plants. Gibberellic acid can be purchased in many garden centers. Its use in artichoke culture initiates bud formation and speeds their development in barren plants. Barren plants in late July through early August can be sprayed with 50 ppm GA3, directed to the center of the plant surrounding the growing tip. In our trials, treatment of barren plants was beneficial only for Green Globe and Green Globe Improved, which required extended low temperatures (less than 50ºF) for vernalization. Barren plants of cultivars that require fewer hours of cold temperatures (Imperial Star and Colorado Star) eventually produced buds as fall temperatures lowered.

Irrigation. Artichokes require about one-inch of water per week. This may be provided by overhead or drip irrigation. Moisture stress may cause a physiologic disorder called Black Tip. The tips of the affected bracts become dark brown or almost black, dry, and leathery.

Harvest. Buds are harvested when they have reached their maximum size, but not gotten tough and too far along in the floral development process. Generally, they should be picked when the lower bud bracts have just begun to separate. Once the top (primary) choke is cut, secondary chokes will develop.

Overwintering. Artichoke plants that were unproductive the first year despite vernalization or GA3 treatments can be dug and placed in two-gallon plastic pots and kept in a cool sunny window. The plants will not enlarge, but will maintain a relatively constant number of leaves. After replanting in the field around May 1, most of the plants should grow and produce buds in July. Attempts to overwinter barren plants in the field with various mulches were found to be generally unsuccessful. If not dug, plants should not be cut but left intact over the winter. Barren plants left in the field survived one very mild winter and produced an abundance of buds in June. If plants do not survive the winter, the dead plants should be removed.

Witloof chicory is grown in two stages. The roots are grown in the summer, lifted from the soil, and the tops severed and discarded. After a cold treatment (vernalization) either in the field or in cold storage, the roots are then replanted and the regrowth forms the chicon that is eaten. Traditionally, the roots are forced in winter in darkened sand-peat covered beds at a constant temperature and humidity. Three weeks after planting the roots, the chicons are exhumed from the sand-peat overburden, cleaned, and shipped to market. The weight of the sand-peat

overburden compresses the leaves into a tightly-furled head. However, the sand-peat adheres to the leaves and the chicons must be trimmed at considerable cost of labor and wasted trimmings. We developed a method to produce marketable chicons in an unheated barn, using a sand-peat mixture for planting the roots and weighted insulation to maintain heat in the forcing bed and envelop the chicons as they grow under pressure. Both methods of forcing will be described.

Field Management. Witloof chicory requires adequate phosphorus, potassium, and magnesium to produce quality roots. Accordingly, the soil is fertilized with 150 lb/A P_2O_5 (supplied as triple superphosphate at 570 lb/A), 300 lb/A K_2O (supplied as muriate of potash at 445 lb/A) supplemented with 140 lb/A MgO (supplied as magnesium sulfate (Epsom salt) at 860 lb/A). Nitrogen fertilizer is generally excluded to prevent excessive top growth in the field and to discourage unfurling of the outer leaves of the chicon during forcing. Nitrogen supplied by decaying organic matter in the soil is usually sufficient for field growth.

Seeds are planted by hand in the first week of July. This ensures that the roots will mature in late fall and allow sufficient cool treatment (vernalization) of the roots for direct forcing without placing them in cold storage. If seeds are planted too early in the spring, the seeds will vernalize in the cool soil and the plant will bolt in the field. Once a plant has bolted, its root can not be forced. The rows are placed 36 inches apart to allow cultivation by a rototiller. If hand cultivation is used, row spacing can be reduced to 24 inches. Plants are thinned 4 inches apart within the rows. Ensure that the soil does not dry out during germination.

In late September, roots of witloof chicory are sampled for maturity. Sample roots are split in half lengthwise and the fingernail-size white patch just below the crown is examined. At maturity, the white tissue is 1/4 to 3/8 inch thick. Roots with patches thinner than 1/4 inch are immature and will not produce tightly furled chicons. Roots with patches thicker than 3/8 inch are overmature and produce chicons of poor quality with numerous subsidiary crown shoots. The optimum root diameter is 1-1/4 to 2-1/4 inches.

Roots are usually harvested mid-October to mid-November. Small amounts can be harvested with a digging fork. For mechanical harvest, use root-crop or modified potato harvesting equipment. The leaves are severed about 1 inch above the root crown and the roots trimmed to 8 inches. Roots less than 1 inch diameter are generally discarded. Roots that branch into two or three forks can be trimmed to one dominant branch.

Immediate forcing is possible if the roots were exposed to low temperatures in the field. If roots must be stored, ideal storage conditions are 32-34°F with 96-98% humidity. A cool garage can be used with the roots draped loosely with tarps or burlap sacks to prevent them from drying.

Forcing of roots.

Temperature. The optimum forcing temperature is 65°F. Since our forcing was done in winter in the basement of an unheated barn, electric heating cables were buried in the sand-peat mixture beneath the roots to maintain the optimum temperature in the bed. Bed heat is unnecessary if the forcing is done in a heated environment.

Forcing media. The planting media is 6-10 inches of unfertilized 1:1 sand:peat mixture. If a heating coil is necessary to supply bed heat, it is placed in the planting media in a serpentine fashion about 2 inches from the bottom of the bed.

Planting roots. Roots are planted to their crowns using a dibble to make the holes. They are planted at a close spacing, providing a density of about 25 roots/ft^2. After planting the roots, the sand-peat mixture is watered thoroughly until water drips from the cell. In the traditional European method, another 4 inches of 1:2 sand:peat mixture is added above the root crowns.

This overburden is also watered thoroughly. In the new method, the root crowns are covered with a sheet of Reemay to form a permeable barrier above the root crowns and then 6-inch batts of insulation to provide heat retention and a cushion for the growing chicons. Next, a sheet of plywood is placed over the insulation batts to support bags of sand that applies 1 pound of pressure/root. In both methods, the forcing bed is draped with 4-mil black plastic to exclude light. Nothing else is done until harvest about 3 weeks later.

Harvesting chicons. Chicons from roots replanted directly from the field can be harvested in 18-21 days. Chicons from roots stored 3-7 weeks can be harvested after 28-30 days. Stored roots partially wither if the humidity in storage is lower that 95%. After replanting the roots in the forcing bed, turgor is regained in several days before the chicons begin to grow. In the traditional method, whole plants are exhumed and the chicons cut from the roots. The chicons are trimmed to remove unfurled leaves and those outer leaves with sand and peat particles adhering. In the new method with weighted insulation, the chicons are cut directly from the roots in the bed and unfurled leaves trimmed. Protect the heads from light even after harvest to keep them white and refrigerate in loosely closed plastic bags. The chicons should not be washed. Roots kept in the bed may produce new growth around the crown. These small "chiclets" are also edible, mostly in salads.

Home Forcing.

Home gardeners not concerned with commercial quality chicons (tight heads) can force the roots with no overburden. Eating quality is not affected as long as forcing is done in complete darkness. Roots can be forced in wooden crates, recycling bins, waxed cartons, garbage cans, or large nursery pots with sides at least 9-10" deep in a soilless mix such as sand or a sand-peat mixture. The root tops can extend above the container, but should be of relatively even height. The soilless mix does not have to entirely cover the roots but should cover at least two-thirds of the root. Water so that the mix is completely moistened. Place the container draped in black trash bags (double thickness) in a dark space at approximately 65ºF. Potential areas include a basement (near the furnace), a closet, or under a tent made of black plastic. Harvest in 3 to 4 weeks.

Fighting Fire Blight: Using the Whole Playbook

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Fire blight ranks among the most serious disease threats to apples throughout New England. It is not a problem every year, but when it is, it can be devastating, particularly on younger, smaller, high-density plantings. The high investment in modern plantings, the increased susceptibility of many new cultivars and dwarfing rootstocks, and the rapid movement of infection from blossoms to the main trunk in small trees make it imperative that the complete set of disease management options be used to reduce fire blight risk throughout the year.

Growers and advisors tend to focus on bloom, and emphasize applications of streptomycin or other antibiotic if disease models indicate risk. This focus is certainly a critical part of fire blight management, but should not be the only management tactic. My colleagues Jon Clements and Win Cowgill and I, have stressed season-long management of fire blight. Another way of looking at it is that to minimize fire blight risk, it's important to use all the tools at your disposal. Or as a football coach might put it, to win, use the whole playbook.

Primary inoculum – winter pruning. Fire blight bacteria overwinter around the edges of cankers in tree wood. It's important to prune out any visible cankers during winter pruning. Cankers are the major source of infectious *Erwinia amylovora* bacteria in an orchard. Fire blight requires a large population of these bacteria, and getting rid of as much of the initial population as possible significantly reduces the time it takes for that to happen. Applying copper or other chemicals will not kill bacteria inside cankers, but only affects bacteria on the canker surface. The wood that contains the bacteria has to be removed and burned or buried.

Inoculum suppression – silver to green-tip copper. Regardless of whether fire blight has been a problem in previous years, at silver tip to green tip, growers should apply copper to the orchard. This spray should go on the whole orchard, not just "high-risk blocks". Leaving trees unsprayed makes them a potential reservoir for *E. amylovora*.

The copper spray will kill bacteria on the surface of any small cankers that may have been missed during pruning. It will also leave a residue of copper that will continue to suppress bacteria as trees approach bloom. To be most effective copper residues need to cover trees thoroughly, so the higher the volume per acre the better. To minimize the risk of tree damage, apply when drying conditions are good, and avoid applying to wet foliage. Don't apply high rates of copper after green tip.

To provide enough copper residue on bark to have some impact on bacteria through to pink without causing russet, apply a minimum of 2 lb. of metallic copper per acre. Copper formulations vary both in percent metallic copper and in how well copper is retained on trees. If in doubt about how much metallic copper a product contains, use the high label rate recommended at silver to green tip. Copper may be used with oil (1 qt./100 gal.), which can act as a spreader/sticker.

Monitor fire blight risk during bloom. To make sure bloom sprays targeting fire blight go on when they should, and aren't wasted when they aren't needed, use fire blight risk forecasting tools. This means having accurate weather data and linking it to a decision support system, DSS. In New England, at present, many growers have free access to NEWA (Network for Environment and Weather Applications; Cornell and the Northeast Reg. Climate Center). They can contract with RIMpro (Marc Trapman, Biofruit Advies, Zoelmand, Netherlands), either individually or with other growers in a group. The importance of knowing when fire blight risk is high during bloom cannot be overemphasized. Monitor risk, and be ready to spray if needed.

Bloom can stretch over a couple of weeks, and cultivars bloom at different times. For example, one of the reasons English cider varieties are so prone to fire blight is their late bloom. Any time flowers are opening, they can be infected, and they need to be treated if risk is high. New, non-bearing trees may produce flowers which can be infected. Normally, these blossoms should be removed by pinching them off before they open. However, the resulting wound can be infected by *Erwinia.* So, don't remove blossoms in wet weather, and spray streptomycin, Cueva or other low-percentage copper, or Oxidate before pinching.

In the year of planting, spray trees right after planting with low-percentage copper, and repeat 2 weeks later to reduce the chance that *Erwinia* from the nursery will be introduced to the orchard.

Sprays during bloom. The most cost-effective material against blossom blight is streptomycin (Ag-Streptomycin, Agri-Mycin, AS-50, Bac-Master, Firewall, Harbour). Kasugamycin (Kasumin) is as effective against bloom blight, but is more expensive. If fire blight risk is high, the first choice and first application should be streptomycin. Adding Regulaid in this spray will increase uptake of streptomycin, particularly in dry weather. Do not concentrate Regulaid – mix it according to actual water volume. If more streptomycin sprays are needed, adding Regulaid may increase leaf yellowing caused by streptomycin.

In order to reduce the risk that *E. amylovora* will develop resistance to streptomycin in New England, it should only be used when infection risk is high. It should never be used after bloom. The one exception is trauma blight, such as a hail storm when weather has been warm and humid. A single streptomycin spray will reduce the risk that wounds get infected.

Several biopesticides are registered for use against fire blight. Those registered in New England include the microbial-based products, Double Nickel, Serenade, Actinovate, Regalia and, and the chemicals Actigard, Oxidate and Cueva. All of the products except Actigard have OMRI approval for use in organic production. In tests done in CT and MA, the effectiveness of biopesticides depended on the severity of disease pressure. When high populations of bacteria were used to inoculate trees, and weather conditions were favorable for infection, only

streptomycin was able to significantly reduce fire blight. On the other hand, with less favorable disease conditions and normal levels of inoculum, the biopesticides were as effective as streptomycin.

Obviously, biopesticides offer organic growers a way to manage fire blight. They can also be useful in conventional management programs. They are an alternative to streptomycin under moderate disease pressure, reducing risk of resistance development. They can also be used after bloom.

Microbial products and Actigard increase disease resistance in plants. They are called activators. Applying these activators in advance of forecast moderate to high risk periods could boost the efficacy of a streptomycin spray, if needed. They need a couple of days for full effect, so the best timing would be pink to as late as mid-bloom. After that, the chemicals Oxidate or Cueva, which kill bacteria on contact, would be an option under low to moderate disease pressure. However, there is some risk of fruit russet with these applications.

Apogee or Kudos to reduce shoot blight risk. The growth controlling chemical prohexadione-Ca (Apogee and Kudos) also makes shoot tissue in apples more resistant to fire blight. The timing and rates recommended vary, because there needs to be a balance between growth and reducing fire blight risk. Prohexadione applications should be based on the susceptibility and value of a block, and timing is done on the basis of growth stage rather than DSS risk forecasts. A standard program would apply one application (3 – 6 oz./100 gal.) in late bloom, when shoots have about 1 to 2 in. of new growth, followed by a second application 2 to 3 weeks later. An alternative program would use lower rates, 1 – 2 oz./100 gal., starting in mid- to late bloom, then two more applications at 2 week intervals.

Biopesticides for shoot blight. Biopesticides that stimulate resistance, notably Double Nickel, have been effective in managing shoot blight. Double Nickel teamed with Cueva, which would reduce bacteria on bark and leaves, have been effective in tests. Other microbial biopesticides and low-concentration copper products have also shown promise in reducing shoot blight. However, these sprays can't stop active infections. The best ways to use biopesticides are still being developed.

Rootstocks and sucker control. Many common dwarfing rootstocks, such as M9 and M26, are very susceptible to fire blight. If possible, get trees on resistant rootstocks such as those in the Geneva series.

Root suckers can be infected by *Erwinia*, and they should be removed. However, ripping or cutting will leave a wound which can be infected. It's better to use a chemical such as NAA to kill suckers, taking care to use rates and application methods that won't damage trees.

Pruning out new infections. As soon as fire blight shoot or blossom symptoms appear, they should be cut out. Both NEWA and RIMpro give estimates of when symptoms should appear given an infection event. Use that information to scout for early symptoms.

But don’t prune out infections during wet or very humid weather. Moving pruned shoots out of a block risks spreading the bacteria, so instead throw shoots on the ground and allow them to dry for a couple of days before moving them to burn or bury.

Fire blight moves quickly, so daily checks and pruning should be done while the disease is active. Prune back to wood that’s at least 2 years old – it’s more resistant. Leaving a so-called ugly stub, a 4 to 6 in. naked stub gives the tree a better chance of stopping bacterial movement, and makes it easier to identify what needs to be cleaned out during winter pruning.

If infections have reached the central leader, discard the tree and replant late fall or early next year.

Managing fire blight challenges growers. Often, it isn’t thought of until there’s an outbreak, and at that point it’s not only damaging valuable trees, it’s also very difficult to stop. The residual impacts of a fire blight epidemic can be felt in an orchard for years. It’s best to use the full set of management tactics to reduce the risk that one happens.

Managing Plum Curculio in Orchards with 'Attract and Kill' and Beneficial Nematodes

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Many apple growers can reduce their use of pesticides, while still harvesting quality fruit, through a set of common-sense practices known as Integrated Pest Management (IPM). IPM means controlling pests using the most economical means with the least possible hazard to people, non-target organisms, and the environment. IPM programs use current, comprehensive information on the life cycles of pests and their interactions with the crop plants, with natural enemies, and with the environment to prevent pests from exceeding economic damage thresholds. In the apple agro-ecosystem, current recommendations to control key insect pests such as plum curculio (PC), and apple maggot fly (AMF) rely on insecticide applications targeting adults. Due to various environmental and regulatory concerns, there is a need to develop alternative and more sustainable management strategies for the most damaging pests. This presentation focuses on ecologically based IPM approaches that have been developed for PC control.

"Attract-and-kill" system for PC control. To successfully manage PC in a reduced-spray environment it is imperative that alternative management strategies consider the ecology and behavior of the target pest. Previously, extensive field research that aimed at screening compounds for attractiveness to PC led to the identification of a synergistic two-component lure. This dual lure, comprised of the plant volatile benzaldehyde (BEN) in association with grandisoic acid (GA), the synthetic PC pheromone, was used to develop an effective monitoring system for PC involving odor-baited trap trees. This novel approach calls for baiting perimeter-row trap trees with GA plus BEN as a practical approach to determining need and timing of insecticide applications against overwintered PCs.

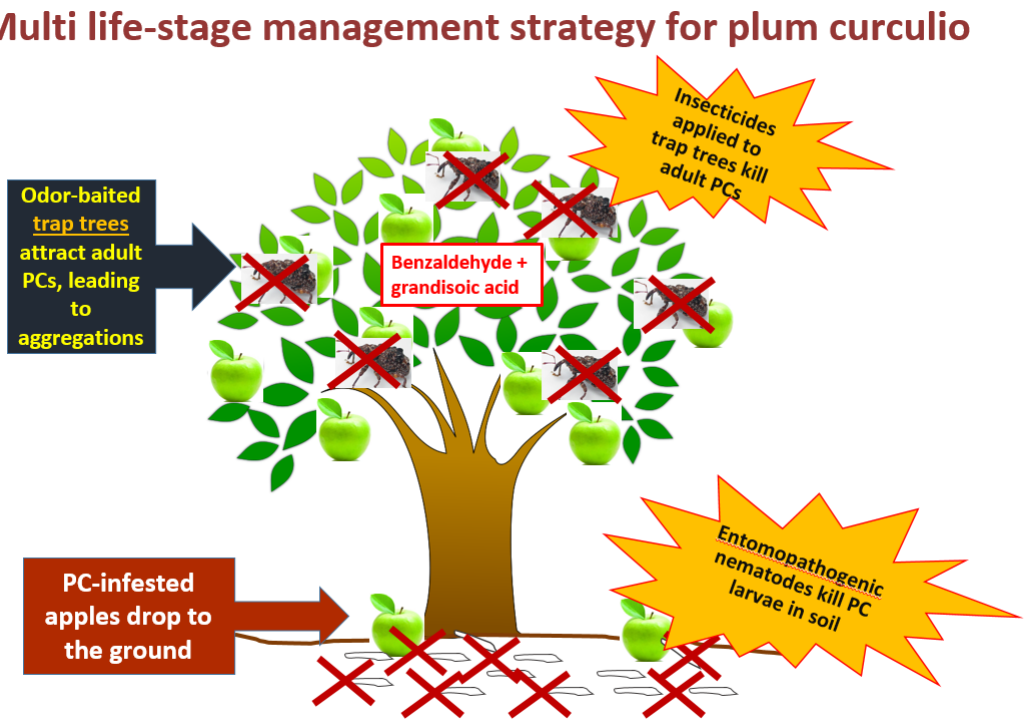
More recently, odor-baited trap trees were evaluated for direct PC control. This new approach calls for baiting the branches of several perimeter-row trees, which results in aggregations of adult PCs on those trap trees, and then confining insecticide applications to those trees only. Results from a 2018 field study involving odor-baited trap trees to manage adult PCs after the full-block petal fall insecticide spray indicate that (1) About 10 times more injury by PC was found within trap trees (17.2% on average) in trap tree plots compared with unbaited 'control' trees (1.5% on average) in perimeter-row plots. Injury in the plot interior was similar in trap tree plots and in plots subject to perimeter-row sprays. This result confirms findings from previous studies indicating that the synergistic lure composed on GA+BEN results in significant aggregations of PC adults and fruit injury in trap trees. These specific insecticide-treated trap tree canopies function as an "attract-and-kill" trap crop for adult PCs. Application of insecticides only to trap trees resulted in the same level of PC control achieved with perimeter-row sprays, with a concomitant reduction in insecticide use.

Biological control of PC. The trap-tree approach makes use of attractive lures to pull adult PCs to selected perimeter-row trees. Because odor-baited trap trees congregate PCs, there is also aggregation of fruit injury by PC on those trees. Recent research has evaluated the use of entomopathogenic (= insect-killing) nematodes (EPNs) to kill PC larvae in the soil. EPNs are very small, soft bodied, non-segmented roundworms that are parasites of insects and occur naturally in soil environments.

A second 2018 field investigation aimed at demonstrating the level to which the EPN *Steinernema riobrave* applied to the soil underneath the canopies of perimeter-row apple trees is effective at killing PC larvae. Results indicate that the application of *S. riobrave* led to a 5.5-fold decrease in the number of adult PCs emerging relative to the untreated check. Therefore, EPNs applied to the soil of those trees effectively kill PC larvae.

In 2019, a field stud aimed at comparing the effectiveness of three EPN species at killing PC larvae in the soil was conducted at the UMass Cold Spring Orchard (Belchertown, MA). Four treatments were evaluated against PC larvae: (1) *Steinernema feltiae*, (2) *S. carpocapsae*, (3) *S. riobrave*, and (4) water as control. Each treatment was replicated five times using emergence (1 m^3) cages. The most effective EPN species was *S. riobrave*, followed by *S. carpocapsae*. These two EPNs caused the greatest suppression of plum curculios when compared to water control. Going forward, *S. riobrave* and *S. carpocapsae* should be tested at a larger scale to see if virulence and PC control remains consistent and effective.

The main goal of the above studies project is to develop an integrated multi-stage management program for PC that minimizes use of insecticides. Combined findings indicate that both PC adults and larvae can be killed successfully using an "attract-and-kill" system combined with biological control using entomopathogenic nematodes.



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How to Raise Fruit in a Changing Climate

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The vagaries of weather impact fruit production more than any other agricultural crop. A single cold day during bloom or winter can result in a total loss of that year's crop. Weather problems can occur from early spring during flower development up through final harvest when you are trying to move fruit from the orchard into the packing house. In the last 20 years the weather patterns have been in the news daily and the erratic patterns have impacted production across the world. This presentation is not meant to discuss what or who is causing the changes in climate but rather to offer some possible factors that need to be considered and probably changed if we are to continue to produce fruit in this country.

There are four general factors of a changing climate that will directly impact orchards: a) increased CO_2 levels, b) shifts in precipitation and temperatures, c) changes in water run-off and availability and d) extreme variability in weather and occurrence of extreme rainfall or hail events. The first three can be mitigated to a large extent, but the variability issue will be difficult to accommodate for orchards. Daily, weekly, monthly and seasonal variations must be considered and not just the average for a season.

Plant Growth. Higher CO_2 levels and higher temperatures will result in increases in photosynthetic rates and potential canopy growth. Of course, this could be good and bad. Fortunately, we have enough choice in rootstocks that growers can select the less vigorous rootstocks in apples and cherries. However, at the present time we do not have acceptable dwarfing rootstocks for other tree fruits.

Weeds growth will also increase with increased temperatures and CO_2 levels. This will require that spring herbicide applications may need to be timed earlier. On the plus side the extended fall temperatures will mean that there will be more time for fall postharvest herbicide applications. Fall application of herbicides has been shown to be a beneficial practice to promote better orchard weed control.

Site Selection & Preparation. Southern exposed slopes will warm up earlier in the spring. Avoid planting early blooming species such as cherries and peaches on southern slopes. Consider cultivars that bloom early versus later blooming cultivars and plant them accordingly.

When rotating land out of an orchard, good site preparation procedures should be followed. Removing the trees should be followed by removal of as much of the old roots as possible. Soil testing at 6 inches and 10-12 inch depths and adjusting nutrient levels accordingly.

On line videos are available that discusses the process of renovation of orchards. (See extension.psu.edu/orchard-site-preparation-bio-renovation as well as a discussion of the use of sorghum sudangrass following orchard removal extension.psu.edu/planting-sorghum-sudangrass-following-orchard-removal . Special effort should be made to increase soil organic matter in new and replant sites. Organic matter can hold considerably greater amount of moisture than sols that are low in organic matter.

Recently in the Mid-Atlantic there has been concern with apple trees collapsing in their third or fourth leaf, a condition that has been described as RAD (rapid apple decline). I believe some of this may be the result of our rush to plant new cultivar-rootstock combinations as close as possible and to crop them as soon as possible. Poor site preparation compounds this problem. Overlain is the changing weather patterns with unusual cold snaps in early winter, erratic rainfall during the growing season and high summertime temperatures.

Windbreaks will probably become more common to reduce the negative effects of erratic high winds. Realize, that native woods can serve as windbreaks.

Irrigation. The majority of eastern tree fruit producers have historically relied on natural rainfall. As mentioned, rainfall has become more erratic. While there may be periods when the ground is saturated there is nothing that can replace the ability to provide water to trees, especially in their formative years to maintain good even tree growth.

Different types of irrigation can serve different purposes. If you are just looking to keep your trees hydrated then drip irrigation is probably the most economical. However, other forms can offer additional benefits. Overhead irrigation, which is more costly, can be used during frost events due to early spring bloom to reduce crop damage. Overhead irrigation also allows for the possibility of evaporative cooling to reduce heat stress in the summer.

Erratic heavy rainfall will require more attention to fungicide and insecticide cover sprays. Pesticide residue is believed to be reduced by one-half after rainfall of 1-2 inches. Current trends have shown that these amounts of rainfall are becoming more common.

Fruit Thinning. Chemical fruit thinning of apples and pears has always been a risky exercise largely due to cool spring weather. With increasing early temperatures, response to chemical thinning for pome fruits may become more consistent. In stone fruit, high temperatures during bloom and after results in a reduction in fruit size. Therefore, under a warmer growing season peaches will need to be thinned harder. Research has also shown that peaches that are blossom thinned induce greater flower bud hardiness the following year and produced larger fruit.

Orchard Covers. Some growers have been producing sweet cherries in high tunnels to reduce the potential from bird damage to the maturing fruit. Aside from the physical protective qualities orchard covers may also help ameliorate damage from changing weather. Certain plastics have the ability to confuse and reduce Japanese beetle damage due to their ability to change the quality of light. This is an area that may hold many promising possibilities. Differentially colored netting can reduce temperatures, fruit sunburn, soil temperatures and photosynthetic stress. This practice is currently being studied in more arid climates such as Washington state. At this point in time, the only benefit of nets may be for reduction of hail damage. However, the occurrence of hail is extremely variable. Orchard coverings may provide the potential for a reduction in frost damage on cold clear nights. In the future results from the work in Washington may shed light on other benefits for eastern fruit growers.

Cultivars. The longer growing season may allow for an extension of the production season. Choosing good frost-free orchard sites with extended warm season into the fall can increase the ability to produce later maturing cultivars. The estimated change in the length of the growing season for the northeast ranches from 9 days in Massachusetts up to 27 days in Delaware. Average increase in growing season just from New York north will be 14.5 days.

Extended harvest window would help to alleviate labor shortages during the harvest period. The main concern on the extended growing season length is early part of the season and the potential for spring frost.

Fruit color will suffer under the increased temperatures. Look for better coloring strains. Maybe McIntosh is a dying cultivar. (I know this could be heresy up here.) Evaporative cooling may become mandatory. Protective covers can reduce fruit sunburn. Sunburn reduction products could become common parts of midsummer and preharvest sprays. In Mexico, growers have permanent wire frames strung over the orchards so they can quickly pull protective nets over the trees should potential for hail approach.

Summary. Orchards are by their nature long term investments and future climatic changes must be considered in their design. Climate change is an evolving process and its impacts on orchard production can be varied. In some instances, the warming temperatures may enhance production and in others may pose a daunting task. It is important that you are aware of what we currently think will happen and take the necessary steps to reduce your risks to future changes.

Growers will need to be more observant and diligent in monitoring for orchard insects, diseases and weeds. Some problems can be alleviated by good horticultural practices such as installing irrigation systems, site selection and preparation. Other new practices such as the use of windbreaks and hail nets may become standard operating procedures.

Additional Reference

The Climate Adaptation Working Group has also produced educational material on the web regarding impacts on Tree Fruit Production specific to the northeastern region of the U.S. The information is located at https://www.adaptationfellows.net/tree-fruit

Examining the Role of Extreme Rainfall in Phosphorus Losses from Agricultural Watersheds

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Introduction

Phosphorus (P) loss from agricultural watersheds is generally dictated by storm size, with large infrequent storms contributing significantly to annual P export (Sharpley et al., 2008). The character of these large storms is currently being altered by climate change, as growing evidence suggests that the frequency and severity of extreme storms are on the rise. Indeed, findings from the US National Climate Assessment indicate that extreme rainfall events – defined as the amount of precipitation falling in the heaviest 1% of daily events – have increased by over 55% in the northeastern US over the past 5 decades (Easterling et al., 2017), faster than any region in the continental US. As such, there is mounting concern over the potential for extreme storms to enhance the risk of P loss from agricultural watersheds (Carpenter et al., 2018).

In this paper, we use long-term data on hydrology, soils, and water quality from two headwater agricultural basins to examine the effects of extreme rainfall on watershed P loss. The study basins are tributaries to WE-38, a 7.3-km^2 (2.8-mi^2) subcatchment in USDA-ARS's Mahantango Creek experimental watershed (420 km^2, or 162 mi^2) in east-central Pennsylvania. The WE-38 watershed has been continuously monitored since 1968 (Bryant et al., 2011), and it contributes to several national research networks, including the Conservation Effects Assessment Project (CEAP) and the Long-Term Agroecosystem Research (LTAR) network. Previous work in WE-38 revealed that daily precipitation is becoming more intense (Lu et al., 2015), however the connections between rainfall extremes and water quality have yet to be formally established.

Methods

The study was conducted in the FD-36 and Mattern watersheds, which are situated in the southwestern corner of WE-38 (Figure 1). We compiled 50 years of daily precipitation data (1968–2018) from a network of long-term rain gauges in WE-38 (Buda et al., 2011). In addition, 15 years (2004–2018) of continuous streamflow and water quality data were available for analysis in FD-36 and Mattern. Streamflow was measured using H-flumes at the outlets of both basins. At each flume, P concentrations in baseflow were measured on a biweekly basis, while programmable stage-activated samplers facilitated year-round sampling of P concentrations during storm events (Sharpley et al., 2008). Standard interpolation routines were then used to estimate daily P loads as a function of P concentrations and daily discharge records.

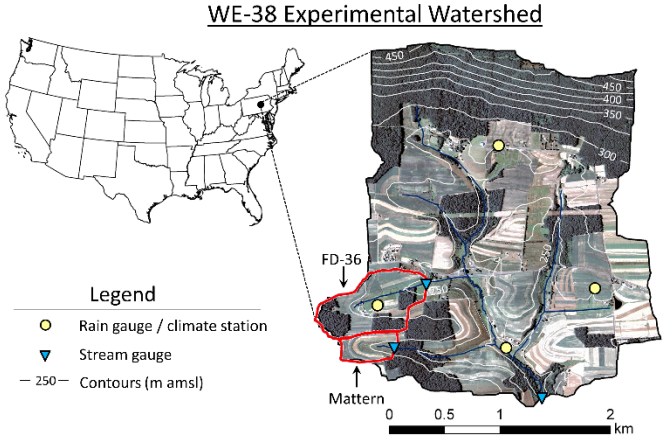

Figure 1: Map showing the location of the WE-38 watershed, as well as the sites used in the analysis of extreme precipitation and watershed P loss. The area of the FD-36 watershed is 40 ha (98 ac), while the size of the Mattern watershed is only 11 ha (27 ac).

We applied long-term data from Mattern and FD-36 to assess trends in extreme annual precipitation and the degree to which these extreme events affected watershed P loss. We defined extreme annual precipitation as the amount of precipitation falling in the heaviest 1% of daily events (Easterling et al., 2017). Trends in extreme annual precipitation were then estimated with Theil-Sen regression, a nonparametric statistical method that is insensitive to outliers (Huang et al., 2017). We employed simple linear regression to evaluate potential associations between extreme annual precipitation and the proportion of P that was exported by these extreme events. Finally, we used findings from Tropical Storm Lee, the largest storm in the 15-year water quality record, to demonstrate the significance of an extreme rainfall event on watershed P loss.

Results and Discussion

Trends in extreme annual precipitation

In the WE-38 watershed, extreme annual precipitation increased by 65% from 1968–2018. On a decadal basis, extreme annual precipitation increased by roughly 5 mm (0.2 in) per decade (Figure 2). Increasing trends in extreme precipitation in WE-38 were broadly consistent with other recent studies of extreme precipitation in the northeastern US. For instance, Huang et al. (2017) reported that extreme annual precipitation increased by 13 mm (0.5 in) per decade from 1979–2014, while a longer term assessment by Easterling et al. (2017) suggested that extreme precipitation rose by 55% from 1958–2016.

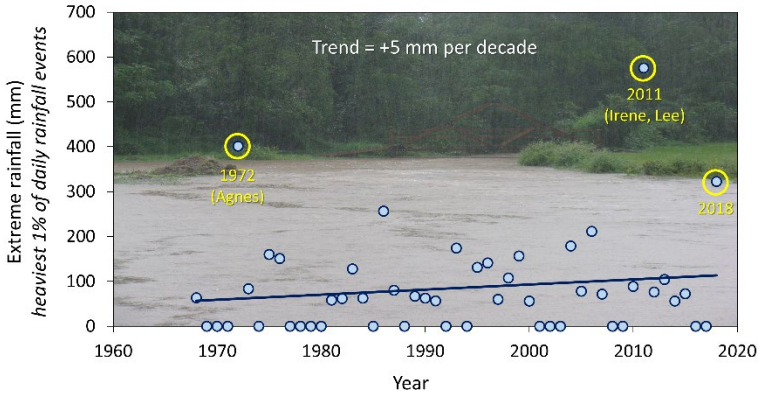

Figure 2: Long-term (1968-2018) trends in extreme annual precipitation in the WE-38 watershed.

Role of extreme annual precipitation in P loss

We found that extreme annual precipitation exerted a strong control on watershed P loss in FD-36 and Mattern. In the FD-36 watershed, for example, the fraction of the annual P load from extreme precipitation events increased with higher amounts of extreme annual precipitation (Figure 3). Similar trends were seen in the nearby Mattern watershed. Thus, years with more extreme precipitation contributed proportionally more P to the annual P load than years with less extreme annual precipitation. These results agreed with a recent study by Carpenter et al. (2018) showing strong connections between extreme daily precipitation and P loads in Wisconsin streams.

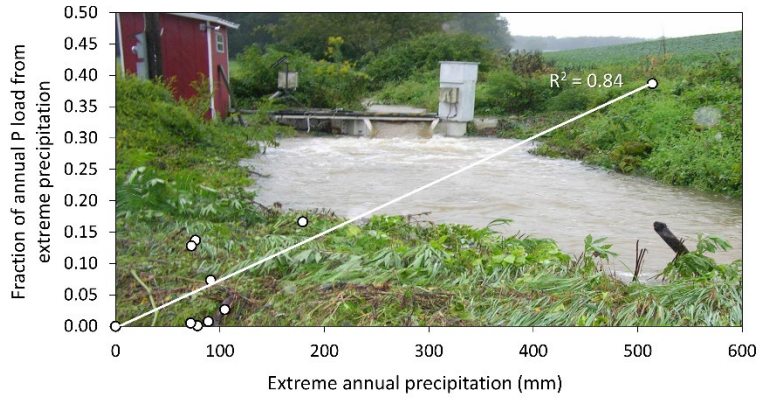

Figure 3: Relationship between extreme annual precipitation and the fraction of watershed P loss resulting from extreme events.

Effects of Tropical Storm Lee on watershed P loss

Tropical Storm Lee (September 7–9, 2011) was the largest extreme rainfall event during the 15-year study period in Mattern and FD-36. This one event delivered 303 mm (12 in) of rainfall over the course of three days, which accounted for 59% of the extreme rainfall that fell in 2011. In the Mattern watershed, Lee accounted for 63% of the P loss in 2011, and 21% of the P loss over the ten-year period from 2007–2016. These results closely dovetailed findings by Hirsch (2012) in the Susquehanna River basin, showing that Lee delivered 60% of the P load in 2011 and 22% of the P load over the previous decade. As the results from Tropical Storm Lee demonstrate, extreme precipitation events, while rare, can intensify P export from agricultural watersheds.

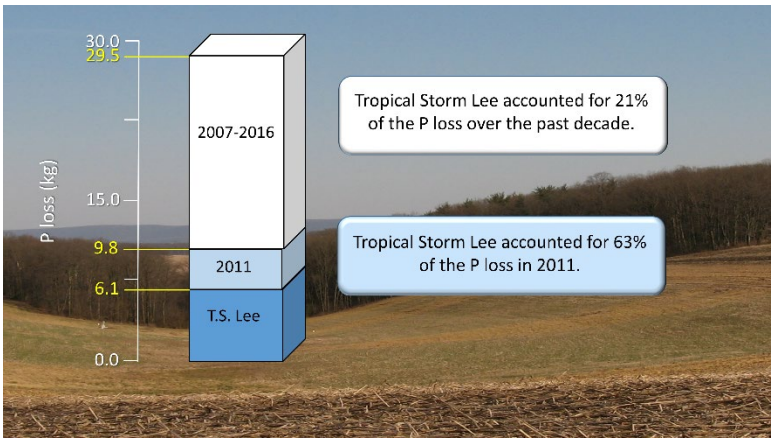

Figure 4: Watershed P loads from Tropical Storm Lee (September 7–9 , 2011) as a percentage of different monitoring periods in the Mattern watershed.

Summary and Conclusions

Our study establishes the important role of extreme rainfall in watershed P loss. Given the increased frequency and severity of rainfall extremes with climate change, P-based management practices may need to be expanded in order to minimize the risk of P loss from agriculture.

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Organic Weed Management in a Changing Climate

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We conducted a thorough review of the literature on this topic, and considered the likely impacts of increasing temperature, CO_2 concentration, and changing precipitation on key organic weed management practices (Table 1).

In the Northeast USA, we generally expect to see further increases in average annual precipitation and incidence of heavy precipitation events in future. This could hinder farmers' timely control of weeds through tillage and cultivation by limiting field access or reducing the number of days when soils are dry enough for these operations. Investing in equipment that allows more ground to be covered at once (e.g., larger equipment) and increasing cultivation efficacy (e.g., through new 'stacked' tool combinations) are two strategies that might help farmers make the most of increasingly limited or unpredictable breaks in the weather.

We expect that mulching, transplanting, and some weed seedbank management strategies could show increased utility in our climate future. By providing effective weed control while reducing erosion and damage to soil structure during heavy precipitation events, mulching has several benefits. Use of natural mulches may additionally build soil organic matter, further improving climate resilience and contributing to climate mitigation. Transplanting can provide crops with a head start against weeds, and may be increasingly advantageous in future as the practice also provides flexibility in the event of wet springs that may delay planting. Seedbank management techniques including soil solarization and tarping may become increasingly effective under warmer and wetter conditions, and could be increasingly helpful if cultivation and tillage become harder to rely upon for timely organic weed control.

Table 1. Summary of expected changes in utility of organic weed management practices under climate change conditions: + indicates positive change, - indicates negative change, ± indicates mixed positive and negative change, and 0 indicates insufficient data. Note that in the Northeast USA, we expect to see further increases in precipitation (↑H_2O) with climate change.

Principles & practices	↑[CO_2]	↑Temp	↑H_2O	↓H_2O
Reducing seedling recruitment				
Plastic mulch	0	±	+	+
Natural mulch	0	+	+	+
Cover crop mulch	0	+	+	+
Tarping	0	+	0	0
Manipulating competition				
Competitive crops & cultivars	0	0	0	±
Increase plant density	0	0	0	±
Alter spatial arrangement	0	0	0	±
Intercropping & living mulch	0	0	+	±
Cover crops	0	0	+	-
Irrigation placement	0	0	-	+
Fertility placement	0	0	-	+
Transplant	+	±	+	+
Seedbank reduction				
Stale seedbed	0	+	±	+
Soil solarisation	0	+	±	±
Harvest weed seed control	±	0	-	+
Short duration cover crops	±	0	+	0
Summer fallow	0	0	0	+
Seed predation	0	0	0	0
Diverse physical weed control				
Tillage	-	0	-	0
Cultivation	-	-	-	+
Flaming	-	0	±	-
Flooding	0	0	0	0
Mowing	-	0	-	0
Grazing & herbivory	-	±	0	0
Biocontrol	0	0	0	0
Hand weeding	0	-	0	0

Stress Mitigation in Vegetable & Small Fruit Crops

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Climate change has the potential to affect fruits and vegetables as temperatures increase. Climate data from the region has shown a steady increase in average temperatures over the last 100 years with average night temperatures in summer months increasing the most. The summer of 2019 was one of the hottest on record in the Northeast with many days in the 90's and nights in the 70's. Many vegetable crops had losses due to the heat. Providing adequate moisture through irrigation is critical in high heat periods. However, water cannot completely compensate for extreme heat.

Photosynthesis rapidly decreases above 94°F, so high temperatures will limit yields in many vegetables and fruits. Plant stomates will close earlier in the day thus limiting gas exchange. Respiration increases with temperature. While daytime temperatures can cause major heat related problems in plants, high night temperatures can have great effects on vegetables, especially fruiting vegetables. Hot night temperatures (nights above 75) will lead to greater cell respiration. This limits the amount of sugars and other storage products that can go into fruits and developing seeds. Because of this increased respiration the plant uses up photosynthates that do not go into yield components.

High air temperatures may result in high leaf temperatures, especially where water is deficient. High leaf temperature may result in heat damage to proteins. Very high leaf temperatures may result in sunburn and scorching. Sunscald of fruits will increase, especially where leaves wilt and reduce fruit cover.

In flowering and fruiting crops, high heat will affect pollen production, often reducing viable pollen numbers. Reproductive parts in plants (anthers, stigmas) may not form properly or function properly. If pollen is transferred to stigmas, pollen germination may be reduced or halted due to heat and desiccation. Reduced pollination can result in smaller fruit or misshapen fruit. Reduced pollination will also reduce seed set in pod crops and sweet corn.

If pollination is successful, early fruit abortion may occur due to lack of photosynthates or heat damage. In heat stressed plants, the hormone balance is affected and there is an increase in abscisic acid that is involved in these abortions.

High soil temperatures can damage surface roots, limiting water and nutrient uptake. This is particularly an issue in crops grown on black plastic mulch. High temperatures affect root crops such as potatoes, especially near the soil surface, by damaging tubers and roots.

On black plastic mulch, surface temperatures can exceed 150°F. This heat can be radiated and reflected onto vegetables causing tremendous heat loading. This is particularly a problem in young plants that have limited shading of the plastic. This can cause heat lesions just above the plastic. Heat lesions are usually first seen on the south or south-west side of stems. High bed temperatures under plastic mulch can also lead to reduced root function limiting nutrient uptake. This can lead to increased fruit disorders such as white tissue, yellow shoulders, and blotchy ripening in tomato fruits.

As growers face the challenges of climate change, there are a number of tools or strategies that can be used to mitigate the effect of higher temperatures.

Managing mulch is one such tool. This includes changing plastic film to white, silver or metalized colors for summer production and the use of natural mulches such as rolled small grain cover crops to reduce soil temperatures. In tomatoes, high soil temperatures have been shown to reduce potassium uptake and increase fruit quality defects (white tissue and yellow shoulder). Use of white plastic has been shown to reduce theses defects. Day-neutral strawberries had higher summer yields on white plastic in our trials in the past.

Radiation blocks or reflective materials can reduce heat effects by reflecting away some solar radiation. Commonly, particle films are used as radiation blocks including kaolin (white clay) based or calcium carbonate (lime) based materials. These are sprayed on plants during high temperature periods. Particle films are commonly used to reduce sunburn in watermelons in southern regions. Wax based reflective materials have also been used in fruits such as apples to maintain color. Research at the University of Delaware and University of Maryland has shown that tomato quality and yield is improved with the use particle films

Shading is another strategy. Commonly, shade cloth or netting is used for this purpose. This netting comes in black, green, white, and reflective aluminum colors and is commonly used at the 20-30% shade levels. Shading is applied during the hottest periods or periods when the plant is most sensitive to heat (such as tomato fruit development). Research at the University of Maryland showed that shading tomatoes during fruiting can improve fruit quality and reduce culls. Research at the University of Georgia on peppers showed similar results with improvement in the number of marketable fruits. Our research with shading of strawberries for summer production showed mixed effects with shading benefiting in some years but not in others. In 2018 and 2019 we also tested effect of shade cloth on tomato and pepper marketable yield. Treatments were no shade, 30% black, 30% Aluminet, 30% red, 22% white, 40% white. In 2018 shade treatment did not have a significant effect on pepper quality or marketable yield. In contrast, in 2019 shade treatments, especially 30% black, shaded plots produced more marketable peppers than the unshaded plots. Yield of marketable first harvest (early Aug) for 30% black was 18x higher than unshaded. Yield of marketable second harvest (Sep) was 2x unshaded. Shade did not reduce internal white tissue in tomatoes to the point of achieving marketability in the 2018 or 2019 trial. Lettuce trials were conducted with no shade, 30% black, 30% Aluminet, 30% red, 30% blue, 22% white, and 40% white. Shade treatments had reduced bitterness in the 2019 trial but in both the 2018 and 2019 trials, variety selection was more important in determining quality under heat stress.

Metabolic and developmental regulators may also have a place in stress mitigation. These are chemicals that are applied to plants and reduce stress through different mechanisms. Ethylene inhibitors such as 1-MCP and strobilurins reduce flower and fruit drop. Hormones such as cytokinins and jasmonates alter different biochemical pathways related to plant stress. Flower or fruit initiating hormones (auxins, gibberellins, cytokinins and combinations) can improve flower and fruit set. Unfortunately, we have few labels for use of these products in vegetable crops.

Water-based cooling can be employed to reduce heat loading in crops and crop environments. Evaporative cooling has been commonly used in greenhouses to cool air entering houses and reduce temperatures for greenhouse grown vegetables. Fogs and misters have also been employed for this purpose. In the field, low water volume sprinklers, either continuous or pulsed, have been successfully used during hot daytime periods for plant cooling. Irrigation timing can also be used to as a tool. For example, by starting drip irrigation soon after dawn, soil under black plastic mulch will remain cooler for longer periods during the day.

Some biological root inoculants have also been shown to reduce plant stress. Mycorrhizal fungi can act as root system enhancers, increasing the effective area for absorbing water from the soil. The University of Delaware has released a Bacillus subtilis bacteria for root inoculation that has been shown to improve plant stress tolerance.

While stress mitigation tools may be more commonly used in fruits and vegetables as the climate warms, adaptive changes should be considered for more long-term stress management.

One adaptive change would be to switch to crops that are more heat tolerant for summer production. Sweet potatoes would be an example of a very heat tolerant crop. Another adaptive change would be to alter planting dates. By planting earlier in the spring (for summer maturing crops) or later in the summer (for fall maturing crops), you can avoid the hottest growing periods and have better production potentially. We have studied the effects of planting dates on broccoli and Brussels sprouts at the University of Delaware. Yields of marketable broccoli changed dramatically with planting date.

Two other adaptive strategies would be to change to switch to more heat tolerant cultivars (for summer production) or to varieties that mature in cooler periods (to match with later plantings). Broccoli trials in 2017 and 2018 showed that Eastern Crown had superior heat tolerance. Past research in a very hot year (2012) showed significant differences between seedless watermelon varieties in heat tolerance. Snap bean trials in 2017 and 2018 identified three varieties with good heat tolerance. Tomato trials in 2019 identified two experimental lines with limited white tissue development under high heat. We also have been evaluated southern highbush blueberries for adaptability to Delaware conditions as our climate warms.

The most effective adaptive strategy is to breed vegetable and fruit crops that are more stress tolerant. For example, currently the lima bean breeding program at the University of Delaware is making significant progress in understanding heat stress losses in lima beans and breeding for heat tolerance.

Up your Adaptation Game with the Climate Adaptation Fellowship: A New Program for Vegetable & Berry Growers & Agricultural Advisors

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What does climate change mean for vegetable and berry growers in the Northeast? How can we best deal with the risks that climate change brings to our farms? The Climate Adaptation Fellowship is a curriculum designed to help farmers, foresters, and service providers improve their knowledge about climate change impacts, and their ability to make good planning decisions related to climate change adaptation. It also provides resources to help participants access localized climate data, which can improve on-the-ground decision making. Lastly, the curriculum helps participants improve their climate communication skills.

The development of the Climate Adaptation Fellowship curriculum was led by the University of Vermont Extension, in close collaboration with the USDA Northeast Climate Hub, the USDA Northern Forests Climate Hub, the University of Maine, Rutgers University, Cornell Cooperative Extension, Pennsylvania State University, the USDA Natural Resource Conservation Service (NRCS), Manomet, and the Forest Stewards Guild.

The curriculum includes course outlines, teaching notes, slide decks, and activities. These materials are free to access and available at https://www.adaptationfellows.net. The curriculum has four modules, tailored for farmers and land managers in the northeastern United States. The modules focus on vegetables/small fruit, tree fruit, dairy, and forestry. The program includes a core set of education lessons and a menu of hands-on activities, and uses a peer-to-peer learning approach to connect land managers and the advisors who work with them. It is responsive to the interests of participants, their skill level, and technical background. Adaptation practices presented in the curriculum (e.g. cover crops, strip tilling, high tunnels) are tailored to a sector-specific audience.

The program is designed to be flexible and accommodate the interests of participants. The minimum amount of time needed to cover all core materials is 4-5 hours. These materials can be delivered in one, two, or three sessions. Program activities require time commitments between 8 hours and two years outside the classroom, depending on participant interest and available funding.

The Climate Adaptation Fellowship curriculum was designed after a careful review of the existing climate-related educational opportunities that currently exist for farmers, agricultural and forestry advisers, and other technical service providers. As agricultural stakeholders, these groups all play an important role in supporting farmers and foresters to adapt to climate change. While there is a demonstrated interest related to climate-related professional development, few

examples of curricula developed with the express purpose of serving this audience and a systematic review of these curricula has not been conducted.

Therefor, and before finalizing the Climate Adaptation Fellowship curriculum, our group conducted a review of 12-programs published between 2001 and 2017. Our findings suggest that successful climate adaptation educators: (a) consider the specific needs of their audience, including topical interests and learning needs; (b) depend on interdisciplinary teams; (c) consider the tradeoffs associated with inclusivity and depth of course content; and (d) use project-based education approaches. The Climate Adaptation Fellowship curriculum was designed with these themes in mind.

If you are interested in running a program using a Climate Adaptation Fellowship module, please contact us. Curriculum developers are excited to partner with you to run and evaluate such programs. We will work with you to seek funding and design a pilot that best meets the needs of your community.

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Read more about our review of climate change curricula for land manager audiences:
Schattman, R. E., M. Kaplan, H. M. Aitken, and J. Helminski, 2019. Climate change curricula for adult audiences in agriculture and forestry: A Review. Journal of Adult and Continuing Education, 25(1): 131-151. DOI: https://doi.org/10.1177/1477971419840670

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.

Assessing Soil Health

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In 2019 the USDA-NRCS Soil Health Division developed several products to help conservation planners and producers assess soil health in a consistent manner. This presentation will focus on: 1) an easy to use and effective in-field soil health assessment method, 2) nationally-consistent soil health laboratory methods, and 3) soil health principles and planning.

The in-field soil health assessment will be used to assist in determining the presence of soil health related resource concerns. This assessment supports the two newly approved resource concerns, aggregate instability and soil organism habitat degradation, as well as soil organic matter depletion and compaction.

The in-field assessment guides the planner through the decision-making process for a variety of soil health indicators by use of decision trees to document the presence of soil health resource concerns. Eleven indicators are defined for use and should be adapted by each State as needed: soil cover, residue breakdown, surface crusting, ponding, penetration resistance, water stable aggregates, soil structure, soil color, plant roots, biological diversity, and biopores.

For laboratory soil health tests, the NRCS recently published Technical Note 430-03, Recommended Soil Health Indicators and Associated Laboratory Procedures. The goal of this document is to provide consistent and standardized laboratory soil test methods that are calibrated for soil, climate, and cropping system.

In 2020, NRCS will use 5 of the recommended indicators as part of a "Basic Soil Health Test:

Organic matter cycling and carbon sequestration: soil organic carbon content measured by dry combustion

Soil structural stability (infiltration): wet macro-aggregate stability

General microbial activity (carbon mineralization): respiration using a 4-day incubation

Food source for soil microbes: readily available or "active" carbon measured by permanganate oxidation

Bioavailable nitrogen: available, organic nitrogen measured as citrate extractable protein

Additional information on updates to the soil health principles and planning procedures will also be discussed.

References

USDA Natural Resources Conservation Service. 2019. Soil Health Technical Note No. 450-03. Recommended Soil Health Indicators and Associated Laboratory Procedures. https://go.usa.gov/xpxqQ

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Peaches are/were my Career … and Clemson Beats Alabama!

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During 34+ years conducting peach research, I learned something every day working with academics, pomologists and fruit growers. The only constant during my career was change, which we all experience daily via social media, TV/newspapers, and our everyday work and personal lives. So what were some of the changes over my career that I foresaw and did not foresee 40 years ago when I started Graduate School?

In Graduate School (Forest Science), the emphasis was learning science, communicating ideas, using one's creativity to answer questions via peer reviewed research, understanding how to write grants to support research, etc. but not how to make a profit in an agricultural business. Once I started as a Horticulture Assistant Professor at an outlying Research and Education Center in South Carolina (never even been in SC before my interview), I was underwhelmed with the facilities (compared to Michigan State, my Ph.D.) and overwhelmed with the industry's problems. The SC peach industry had declined from 40,000 acres in the late 70s down to ~30,000 acres when I arrived in 1985 and continued to downsize over the next 10 years before research and other factors stabilized the industry. The problems in the 1980s were many but it boiled down to 3 things: (1) loss of effective fumigants for nematodes lead to a dramatic increase in tree death (100s of thousands of trees per year); (2) winter and spring freezes in the early 80s; and (3) increased competition from CA in fruit availability, quality and appearance.

I was trained in whole tree physiology, classical genetics, and scientific principles, but not in horticulture, pomology or peach culture. I soon learned that to tackle difficult production problems, it helps if you have no preconceived notions on how to approach a problem. Whether it involves the scientific method, common sense, serendipity or even shifting an accepted paradigm, one should be flexible and willing to think outside the box --- and be patient! It was obvious to a novice like me that applied research would provide some short-term benefits but basic research would be necessary for long term solutions to the more difficult biological, environmental, and marketing problems. I had no idea 30 years earlier how long it would take for the basic research to pay off and the obstacles it would face to being accepted by the public. However, my early basic research is now coming to fruition as it has created new technologies to assist current and future fruit growers in producing peaches and other stone fruit more efficiently and profitably in a high-risk agribusiness.

When I started, I needed to read up on the history of peach growing especially in the Southeast and see the orchards and talk to the growers in person (though my speech soon exposed myself as a northerner or even, God forbid, mistaken for a Yankee). I soon learned you needed to have your clientele comfortable with you before you can really communicate and exchange ideas. Once I learned how not to be too blunt and matter of fact, the growers were very warm and welcoming. Y'all, fixin', grits, goobers, sugah, bless your heart, Mr. Billy, Miss Hattie, etc. were quickly incorporated in my vocabulary and vernacular. If you cannot empathize with your growers then you cannot fully understand how important it is for your research to make a difference for them and others.

Brown Rot: Getting Better or Getting Worse?

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Brown rot of stone fruit, primarily caused by the fungal pathogen *Monilinia fructicola* in the Eastern United States, is arguably the most economically devastating disease of stone fruit and the disease that poses the greatest threat to the industry worldwide. Blossom infections can lead to reduced crop loads and sporulate causing secondary infections of young shoots, senescing bloom, and young fruit. Similarly, young twigs or shoots that can become blighted, sporulate, and infect developing fruit. Green fruit can be infected prior to pit hardening with infections remaining latent until fruit mature, develop color, and covert starch to sugars. As fruit approach harvest maturity, they become increasingly susceptible to infection and numerous secondary infections cycles may occur. After harvest, infected fruit and blighted shoots remaining on trees may development into fruit mummies and overwintering cankers, respectively.

Despite reports of resistance to DMI fungicides and reduced sensitivity to strobilurin (QoI) fungicides in isolates and populations of *Monilinia fructicola* in the eastern United States, these fungicides, along with new generation succinate dehydrogenase inhibitor (SDHI) fungicides, remain the cornerstone of brown rot management programs during the month prior to harvest. Recently, a new SDHI fungicide (FRAC 7), Miravis (pydiflumetofen; Syngenta), and a new DMI fungicide (FRAC 3), Cevya (mefentrifluconazole, BASF) received registration for control of brown rot on stone fruit. To evaluate the efficacy of these products, in 2019 a trial was conducted at the Mountain Horticultural Crops Research and Extension Center in Mills River, NC.The orchard site was a mature planting of 'Winblo' peaches. Treatments were applied on approximately 10 to 14 day intervals, using a gas powered backpack sprayer (~100 gal/acre) on the following dates: 30 Mar (1-bloom), 10 Apr (2-petal fall), 25 Apr (3-shucksplit), 1 May (4-1st cover), 15 May (5-2nd cover), 23 May (6-3rd cover), 5 Jun (7-4th cover), 21 Jun (8-5th cover), 2 Jul (9-6th cover), and 15 Jul (10-7th cover). Total precipitation in Mar, Apr, May, Jun, and Jul (up to 22 Jul) was 2.8, 9.5, 4.2, 7.1, and 4.0 inches, respectively. On 8 Jul, two fruit per tree were inoculated with a conidial suspension of *Monilinia fructicola* ($1x10^5$ conidia/ml) to enhance brown rot pressure in the block.

To evaluate brown rot incidence on mature fruit, 40 asymptomatic peaches (excluding the inoculated fruit) were harvested from each single-tree replicate on 16 Jul and stored at room temperature (70°F). The incidence of brown rot on harvested fruit was evaluated on 18 Jul, 20 Jul, and 22 Jul. The incidence of disease was expressed as the number of fruit with brown rot out of five fruit with eight such collections assessed for 4 single-tree replicates per treatment. In addition, the incidence of brown rot on fruit remaining on trees in the orchard (i.e. pre-harvest) was evaluated on 22 Jul- six days following the final fungicide application. The incidence of brown rot on non-harvested fruit was expressed as the number of fruit with brown rot symptoms out of 5 fruit, with 10 collections assessed per 4 replicate trees per treatment. Disease incidence data and fruit finish data were subjected to analysis of variance (ANOVA) for a randomized block design using accepted statistical procedures and software (i.e. Generalized Linear Mixed Models (GLIMMIX)) procedure of SAS (version 9.4; SAS Institute Inc., Cary, NC).

Due to average precipitation and high relative humidity, pressure was fairly high for brown rot throughout the summer. As expected, the incidence of brown rot on harvested fruit increased over time. The program that included Miravis and the Luna Experience program demonstrated the greatest efficacy throughout the post-harvest rating period. However, the incidence of brown rot in these programs was not differ significantly from the Cevya program or Indar 2F program. Due to heavy disease pressure, the incidence of brown rot was also rated in the field ("pre-harvest") one week following the final fungicide application. Brown rot incidence in the field ranged from 1.0-64.0% with the Miravis program having the lowest incidence (numerically) of brown rot. No russeting was observed on the peach surface across any of the treatments.

	Treatment programs (amt./A)	Timing*	Incidence of brown rot on 18 Jul (%)**	Incidence of brown rot (%) on 20 Jul**	Incidence of brown rot in field on 22 Jul (%)**
1	Untreated	na.	42.5 ± 3.5 a	66.3 ± 7.7 a	64.0 ± 8.8 a
2	Luna Experience 8 fl oz Captan 80WDG 3.75 lb	1,2,9,10 3-8	0.0 ± 0.0 c	1.4 ± 0.8 d	4.0 ± 0.8 c
3	Captan 80WDG 3.75 lb Cevya 5 fl oz + Cohere 8 fl oz/100 gal	1C-5C 6C-7C	1.9 ± 1.2 b	9.0 ± 4.0 cd	5.0 ± 3.1 c
4	Captan 80WDG 3.75 lb Indar 2F + Cohere 8 fl oz/100 gal	4-8 9,10	1.9 ± 1.2 bc	8.8 ± 3.8 cd	3.5 ± 2.2 c
5	Captan 80WDG 3.75 lb Pristine WG 14.5 oz	4-8 9,10	3.1 ± 2.4 bc	15.3 ± 4.2 c	10.5 ± 6.6 c
6	Miravis 5.13 fl oz + Cohere 8 fl oz/100 gal Captan 80WDG 3.75 lb	1,2,9,10 3-8	0.0 ± 0.0 c	1.3 ± 0.7 d	1.0 ± 1.0 c
7	Captan 80WDG 3.75 lb	4-10	7.5 ± 2.3 b	42.5 ± 2.7 b	39.0 ± 7.4 b

Why I Gave Up on Cherries, However, if you Insist…

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Amongst all of tree fruit growing in New England, cherries are the hardest to produce a profitable crop successfully. No doubt in my mind. Over the years, I have grown sweet and tart cherries at the UMass Orchard in Belchertown, MA and I have traveled widely with knowledgeable cherry experts. A saying that sticks with me is "cherry trees love to die." So true, but that is only half the story and arguably the easiest one to overcome. Oh yea, another saying "it's easy to grow cherry trees, but it's hard to make money growing cherries." Bringing a cherry crop to fruition annually and actually making some money on that is hard. If you really want to make money I say grow Honeycrisp apples. But if you insist…

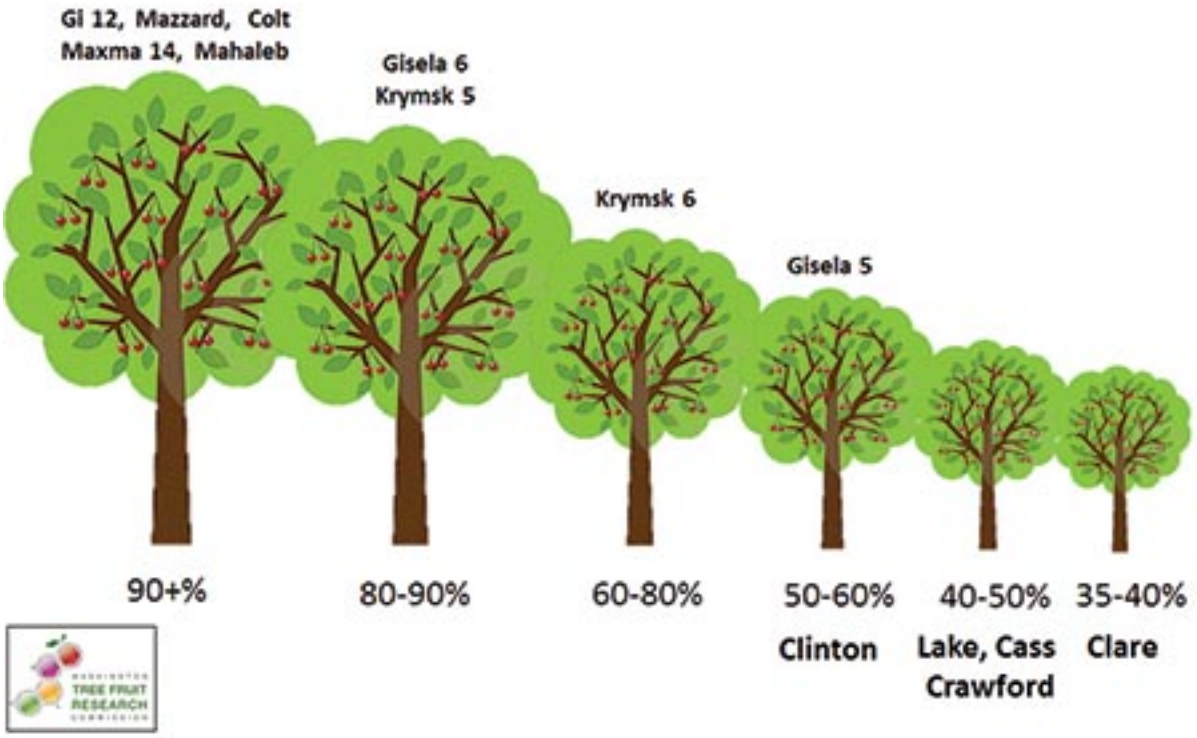
- Site – cherry trees/rootstocks don't tolerate wet soil. If you even begin to think it's too wet, it is! Plant apples. (Well, if it's not too wet!) Also, cherries like sun. And heat. Need full sun and probably don't try to grow north of the New England banana belt states of Massachusetts, Connecticut, and Rhode Island. Well maybe extreme southern Vermont and New Hampshire are OK. (Arguably.) Maine? Forget it probably, at best maybe tart cherries.
- Rootstocks – the dwarfing Gisela 3, 5, 6, and 12 rootstocks are recommended for both sweet and tart cherries. Many nuances here, but Gisela 6 would be my choice if planting a free-standing (more-or-less) dwarfing sweet or tart cherry. Gisela 3 or 5 might OK if planting very high density such as SSA (super-slender-axe). Dwarfing Krymsk rootstock has been advertised, but I don't have experience there. Very dwarfing rootstocks (Clinton, Lake, Cass, etc.) are being bred at Michigan State University but they are not widely tested (yet). Non-dwarfing rootstocks such as Mazzard are not precocious and you will need a ladder. More information: http://treefruit.wsu.edu/web-article/cherry-rootstocks/ and http://giselacherry.com (where there is a link to some excellent pruning and training videos).
- Pruning and training – cherry trees fruit on spurs on older wood similar to apples. But they also form flower buds at the base of last year's shoot growth. Cherry size, particularly for sweet cherries, decreases as wood and spurs age. Renewal pruning is more vigorous than apples. Dormant pruning for renewal and then post-harvest summer pruning for opening up the canopy are recommended. It's easy to develop cherry structural wood on free-standing trees if branching is promoted in the early years. Bud removal, PGR's, and/or heading cuts can be used to develop structural and fruiting wood. Frankly, I would not recommend any other kind of pruning and training for sweet

cherries other than a central-leader (more-or-less) such as the Vogel Central Leader as seen here: https://catalog.extension.oregonstate.edu/pnw667 If you want to do a small planting for farmers market, then SSA on Gisela 3 might be OK. Tart cherries are a bit more forgiving than sweets and are often pruned simply with branching to let light into the canopy. For both sweet and tart cherries maintaining an open canopy with light penetration is important to keep fruiting wood throughout the tree.

- Bacterial canker – bacterial canker is the ever-present nemesis of sweet cherry. It's development is favored by cool, wet weather in the spring and fall. Pruning is not advised when it is wet, and fall and spring copper sprays are essential to keep it at bay. Bordeaux mix, although most onerous to make, is probably the best copper spray for bacterial canker. Varieties differ somewhat in susceptibility, but that is not well documented. Tart cherries are less susceptible to bacterial canker than sweet cherries. Keeping trees stress-free (good sites) helps a lot. For more on controlling bacterial canker of cherry: http://umassfruitnotes.com/v79n4/a3.pdf
- Birds – the biggest pest of sweet cherry. (Well, deer are bigger, and they love to eat sweet cherry foliage of young trees. Hint, hint, deer fence.) Exclusion/netting is most effective and probably mandatory. Bird repellent sprays have been tried, but did I mention netting is probably mandatory? If you keep up with the sprays, or are willing to accept some loss, you might get by without netting. But I have seen birds -- particularly cedar waxwing -- clean house of small blocks of cherries. Sweets are way more favored than tarts, and early cherry varieties seem to have greater predation, I guess the birds get tired of them or more fruits become available? I don't think you can make money without bird netting on sweets.
- Cracking – guess, what? In addition to the bird nets, you probably need to cover sweet cherries with a waterproof cover (plastic or synthetic fabric typically) to keep them from cracking just as they are ready to harvest. Rainwater on the fruit and through root uptake causes cherries to swell and crack. If you can afford a very-high tunnel such as Haygrove (among others) go for it. Some growers build their own covers ala Voen covers which are tent-like. Good luck with that structure. Blowing off the rainwater or spraying calcium chloride during the rain helps, but its a short term and somewhat ineffective solution. Sweet cherries are way more susceptible to cracking, in fact tart cherries don't readily crack. And there is a sweet cherry variety difference, more on that upcoming.
- Pest management – cherry leaf spot, brown rot, plum curculio, cherry fruit fly, Japanese beetles. All kind of run-of-the-mill stuff controlled with scouting and timely fungicide/insecticide sprays. Oh oh, did I mention spotted wing drosophila? That's new, and quite serious in cherry. (Actually SWD was first found in North America in Oregon in cherries, I believe.) Another good reason to grow apples.
- Varieties – what you been waiting for, right? For sweets, Regina is no doubt my top choice. Somewhat resistant to cracking, large size, very tasty if left long enough to ripen properly. But late blooming (and harvest), shy-bearing, pollination seems to be an issue.

Need to have another variety with late bloom, Hudson has been advised among others. (Too bad Hudson is otherwise a mediocre cherry.) ReTain or Harvista application might help fruit set. Otherwise, for sweet cherry, I don't have much else for recommendation, they are all good if left to fully ripen. Rainier is good and seems to bear every year, but cracks readily. The Pearl series are good, but Black Pearl is best in my opinion. For tart cherries, Balaton is superior to the old stand-by Montmorency, but it has a tendency to be shy bearing. Also late harvest. Jubileum and Danube seem to have some issues, although Jubileum is worth a try. I am not so sure Danube is winter hardy?

So there you go. Are you bored? Are you a glutton for punishment? Do you think growing apples and peaches is a piece of cake? Do you have a bankroll? Do you mind losing money for awhile, and then maybe making money every other year or three at best? Is your orchard in southern New England? Do you have an excellent site? If so, then go ahead, be my guest, grow cherries. If not, grow Honeycrisp...



http://treefruit.wsu.edu/web-article/cherry-rootstocks/

Peach Rootstocks are Another Story …

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Stone fruit growers face multiple challenges when growing profitable but high-risk crops such as peaches or nectarines. Some of the more common constraints when planting/replanting an orchard site to peach are climate (frost, frequent rainfall), soil (poor drainage, high pH), soil pests (nematodes, Armillaria root rot, crown gall, Phytophthora rot), replant disease (no rotational crop), vigor vs. labor requirements (pruning, thinning, harvesting), and pesticide challenges (few soil fumigants). Since the 1800s, U.S. peach orchards were primarily planted on virgin land with peach seedlings used as the rootstock of choice. These rootstocks were often seeds from cannery peaches such as Lovell and Halford. When good orchard land became limited, replanting peach after peach on the same site led to replant issues that limited productivity and required using new rootstocks. Unlike Europe, where non-seedling, Prunus rootstocks were bred and selected for high pH soils in the mid-1900s, the first U.S. rootstock breeding programs in the mid-1900s were for nematode resistance with rootstocks such as Nemaguard (released in 1959) and Nemared (1983) being released after years of testing. Followed shortly after by a cold hardiness breeding program in Harrow, Canada that selected Siberian C (1967) and Harrow Blood (1967) rootstocks. Today with tissue culture and other progressive propagation technologies, many new Prunus rootstock cultivars are propagated asexually as they are often interspecific crosses.

As happened with apples and then cherries in the recent past, there now are many new rootstocks for peach being released and offered by nurseries that often have not been tested more than one orchard rotation. As the peach trial coordinator for the NC-140 regional project, we have been able to test new rootstocks before they were commonly available to the growers. Reports of how these new rootstocks have performed in comparison with the old standards of Lovell and Halford can be found in past and recent issues of the Journal of the American Pomological Society and some will be summarized in this article. For New England growers, the only trials nearby are from Belchertown, Massachusetts and then the next closest is Geneva, NY. Older (~20 years ago) trials included Vineland, Ontario.

After 30+ years of doing peach rootstock trials, if replant diseases, nematodes or other issues such as labor or high pH soils are not a problem, then the most productive rootstocks have been peach seedling rootstocks. Lovell and Guardian® have been the most productive with Halford and Bailey being almost as good. Other vigorous peach seedling rootstocks have been acceptable too. Nemaguard is very productive but is limited to warmer climates and where bacterial canker is not a problem. Lovell, Halford and Bailey are susceptible to root-knot (RK) nematodes and getting virus indexed seed can be a limitation as nurseries are not carrying seed orchards of these very old varieties. Bailey grows a slightly smaller tree and is more tolerant of winter cold and lesion nematodes, but availability could be limited. Guardian® is vigorous and RK nematode resistant like Nemaguard but also provides resistance to bacterial canker or the Peach Tree Short Life Syndrome in the southeastern U.S. It also has survived winters very well in trials except maybe less so in Ontario.

Newer clonally (cuttings) propagated peach rootstocks such as the Controller™ series from California have been more yield efficient and reduced vigor than standard sized peach rootstocks in recent trials. Controller™ 6, 7 and 8 might be choices for higher density peach plantings though testing is limited outside of California. Other size controlling rootstocks (plum hybrids) for peach that might have some promise are Krymsk®1 (only in cooler regions), MP-29 (southern origin, Armillaria and bacterial canker resistant), Rootpac® 20 and 40 (bacterial canker susceptibility?) and Empyrean®2 (bacterial canker issues). Other rootstocks (all hybrids) showing some potential are Viking (vigorous, productive, replant tolerant), Atlas (very vigorous, productive), Rootpac® R (vigorous, productive, bacterial canker issues), and Krymsk® 86 (tolerates heavy soil, good anchorage, disease resistance).

As for recommendations for New England, if tree vigor is desired and the sites are not marginal as far as cold for peach, then Lovell, Halford, Bailey or Guardian® will be good choices. If lesion nematodes are a problem then Bailey or Guardian®. If the orchard site is marginally too cold for peach then Bailey would be best. Krymsk® 1 (Russian rootstock) has had survival issues but has done ok in the colder areas and looked reasonably good at Belchertown, MA. It would be for pedestrian orchards as it can be as small as 40-50% of Lovell rootstock. MP-29 produces a very nice compact, productive tree (60% Lovell) but availability and the lack of testing in the North warrants a wait see before planting it. The UC Davis Controller™ 6, 7 and 8 semi-dwarfing rootstocks have survived at northern locations (MA, NY, CO, UT) and are interesting to try for higher density plantings. It is unknown if they have experienced an early winter or a very cold winter so they should be planted with caution.

Also available from the California nurseries, the Spanish Rootpac® series has had significant mortality in the South on bacterial canker test sites. Of these rootstocks Rootpac® R has been the most widely tested and has survived and yielded well outside the South including MA and NY. Other rootstocks being propagated in California that are very productive for peach and have had excellent survival in MA and NY are Krymsk® 86 and Viking. Krymsk® 86 is deep rooted and tolerates high winds but might have some bacterial canker issues on sandy soil, while Viking is very vigorous and can be susceptible to windthrow on wet soil, but is very replant and bacterial canker tolerant. Overall, there are many rootstock cultivars now to choose from but availability (budded to a desired scion cultivar) greatly limits choice and with a 15-year investment on the line, choosing a peach seedling rootstock for sites with no major problems is the safest route to take unless a semi-dwarfing orchard is desired.

Peach farming is high risk but also can be high reward so further rootstock testing is necessary to reduce the risk of tree and crop losses due to the many factors that negatively affect orchard profitability. The future of growing peaches in the United States via rootstock improvement remains challenging yet promising.

Innovative Peach Growing and Selling Strategies (Grower Panel)

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Aaron Libby, Libby & Sons U-Picks

Libby & Son U-Picks is a third-generation fruit farm in southern Maine, located 30 miles west of Portland and 90 miles north of Boston. We grow Apples, Blueberries, Raspberries, Peaches and Plums. All of our over 35 acres of fruit is sold by Pick-Your-Own, no wholesale nor pre-picked fruit. We dedicate our harvest season to the pick-your-own experience, offering live music & entertainment, shuttle rides, picnic areas and many photo ops throughout our orchard. We produce and offer many value added products like donuts, smoothies, caramel apples, kettle corn, concession foods, wood fired pizza and draft beer.

Growing Peaches in Maine is growing to the extreme, very Feast or Famine. Tree ripened peaches have a very high demand with a premium value. However, Maine's frigid winters and cold springs create inconsistent yields.

We grow 10 varieties of peaches on Bailey, Lovell and Guardian rootstocks. Most are traditional yellow flesh varieties, but we do have two flat or donut peach varieties and one traditional white variety. Most of our peaches are planted at 12' x 20' spacing and trained in a traditional Open Vase system. With one exception, we did a trial row of higher density Quad V training. For our production we feel the 12' x 20' Open Vase training is the best balance for yields and ease of customer picking.

Elly Vaughan, Phoenix Fruit Farm

In my presentation, I will discuss some alternative pest management strategies in peaches. I have been managing my orchards without herbicide, and without organophosphates. I will touch upon some pros and cons of going herbicide and organophosphate free, how it has worked out in my orchard so far, and why I have chosen to use these alternative practices. I will talk about my

journey with the Eco-fruit program, what it means to use advanced IPM, and how those principles have informed my production decisions.

I will also talk about pick-your-own peaches, the pros and cons of that, and why I chose to start doing PYO peaches. I will make some points about pick-your-own peaches as a marketing incentive. It's a less common PYO crop and has proven to be very popular, and gets people out to the farm. I will also talk about the different marketing avenues I've used to advertise for pick-your-own and the store, and what the results have been with those. I will mention the Eco-program as a piece of my overall marketing strategy as well.

I can also discuss wholesale vs retail vs PYO peaches, and my experiences with each of these outlets as a small, newly-established orchard.

Andre Tougas, Tougas Family Farm

Tougas Family Farm is a 120 acre fruit farm in Northboro MA. We grow strawberries, sweet and tart cherries, blueberries, blackberries, peaches, nectarines, apples, and pumpkins primarily for U-Pick harvest. We have transitioned our peach and nectarine plantings from open center to perpendicular-V, and have now settled on Quad-V trees, spaced 16’ between rows, 7-8’ in row. We have found that Quad-V trees are easier to maintain a 10’ height and produce fruit uniformly down to 3’ off the ground, optimal for a pick-your-own orchard. Summer pruning the centers of the trees is absolutely necessary to keep production in the bottom of the trees. Ideally during the year of planting four main leaders are selected, spread flat with clothespins and trained to bamboo. The bamboo sets the angle of the leaders for a consistent fruiting wall, allowing for the use of a Darwin-type string thinner and potentially hedging. Much of our peach crop is harvested in mid-August to mid-September, the July varieties have been removed due to poor size, flavor, and excessive split pits. Some of the varieties we grow and like are Canadian Harmony, Coralstar, July Elberta, Fantasia, Messina, and Saturn.

Climate Battery System in Canada for Heating Tunnels for Winter Greens Production: Low Cost & Zero Rowcovers

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Starting out

In 2017 we decided to increase winter greens production on our Zone 5b farm by building a 32ft x144ft greenhouse. The goal was to produce lettuce and other less hardy winter crops in abundance. We also wanted to grow early tomatoes, planting out in mid March. We didn't want to burn a lot of fuel or spend a lot of time on row covers to get this done. When I came across the climate battery idea, it seemed too good to be true. Being a bit of a compulsive risk taker (AKA a farmer) I decided to build one. At the time, I could not find an example of a climate battery system that had been installed in a cold and wet region. So I bought a set of plans from an engineering firm in Boulder Colorado that is specialized in climate battery greenhouses for the cannabis industry in the western part of the USA.

A climate battery is array of fans connected to buried pipes in a greenhouse. When the greenhouse heats up on a sunny day, the fans turn on, sending the warm air through the pipes. This heats the earth around the pipes, storing heat for the coming night. Once temperatures drop below a set point, the fans turn back on. Now the air in the greenhouse is colder than the earth, so the earth is being drained of the stored heat and the greenhouse is heated.

The build

Construction went well, but mistakes were made:

1. The excavation contractor, my own common sense, and smart friends who came by, all agreed that a layer of clear stone with free drainage to daylight should go in under the first layer of air pipes. I asked the engineers from the rain shadow of the Rocky Mountains about this, and they assured me that it would not be necessary. It was necessary! We fixed this by hiring a mini excavator to dig trenches from the outside of the greenhouse into the climate battery modules and backfilled the trenches with clear stone. We also installed a 3ft wide skirt of greenhouse plastic covered with landscape fabric around the perimeter of the entire house.
2. The engineers insisted that in-line turbine fans, which they sold for $2000 each, were the only kind of fans that would work. I bought them, and then found out that $200 horizontal airflow fans from Northern Tool are just fine for the job.
3. We made the hole for the climate battery too close to the edge of the greenhouse. This weakened the holding power of our pipe foundation, making us install another set of extra-long pipes to secure the greenhouse. Having the hole so close to the edge of the house also increased construction costs.

Looking back, the main take away is to seek out locally adapted advice. In our case, this meant providing ample drainage with crushed rock under the battery and making sure the water coming off the roof is channelled well away from the foundation.

Using the System

We have been using the climate battery for two and a half years now. For winter greens, we pull our tomatoes in mid October and seed the next day. We start harvesting the greens in late December or early January, depending on how long the field tunnels hold out. The climate battery fans are turned on at the same time that the winter greens are planted. We set the thermostat to turn on at 70F (21C) for the high temp switch and 28F (-2 C) for the low temp. This means that we are storing heat all day any time it's sunny, but not pumping it out at night until the weather gets really cold in December. This gives us lots of stored heat to use later on.

The greens have grown well. Yields are clearly better than in the unheated tunnels and regrowth is excellent. The system is able to keep temperatures warm enough to harvest radish, cilantro, EZ leaf lettuce and other less hardy greens all the way through the winter. Our coldest night last year was -5F (-20C). The tops of our greens froze, but the soil stayed thawed and there was no damage to our crops. We hope to have temperature monitoring technology installed for this winter to give us more data, but for now, the crops are telling us the system works.

In early March, we clear out the last of our greens and plant out tomatoes, a row of pole beans, and a few other warm season crops. On planting day, we turn on the forced hot air oil furnace. It is set to 50F (10C). Last season we used about 24 US Gallons (90 Liters) for the whole spring heating season. The climate battery seems to keep the house warm all the time except for a few hours in the early morning on particularly cold nights. We are considering setting the furnace higher, in keeping with standard practices. Paying a lot for extra early tomatoes might not be worth the cost until we are more experienced with heated production techniques.

Final thoughts

Since building our climate battery, I found out that many others in North America have built them as well. In the very small world of climate batteries, an early leader has emerged, Tim Clymer from Threefold Farm in Pa. He has shared documentation of Climate Battery performance on his website that is the best place to start if you want to learn more about this promising new technology. If you are thinking of building one or would like to learn more about our experience, please get in touch.

Insure, Protect, and Track: Winter Growing Confidence through Technology

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Surprises. Details. Certifications. The daily life of farming, especially in winter. If you've found picking spinach in January with frozen fingers is the life for you, I have some good news: many everyday issues can be addressed and mitigated with (increasingly) affordable and simple technology. Software, sensors, controllers, cameras, internet, analytics, the cloud, and mobile devices are all readily available and constantly being adapted to solve many of the daily struggles farmers face.

Sensors and monitoring solutions provide protection from malfunctions, human errors and accidents often before they occur or scale into disasters. Frozen greenhouses, warm freezers, burst pipes, certification requirements, dry crops, no internet, burnt out pumps, unknown causes or flooded basements all have solutions from dozens of different suppliers and companies. Davis, Onset, SensorPush, Ubiquiti, Monnit, Sensaphone, Temp Stick, Toro, Irrometer are just some of many companies being used by farmers for all sorts of applications.

Choosing sensors and monitoring equipment comes down to the value of what you are protecting and what you can afford to lose. A $500 sensor system seems like a bargain if it saves you from one $10,000 disaster. Just find a farmer who has lost freezers, tunnels or rooms full of produce because a compressor, heater or vent failed, and ask them what they would have paid to prevent that.

Each company has different features for different applications, quality differences, and a list of pros and cons to consider. Davis provides renowned and fairly affordable weather stations complete with data logging and mobile apps; Toro makes some useful smart and affordable irrigation controllers; Onset has an extensive line of ag focused data logging and monitoring solutions, SensorPush and Temp Stick are two of many companies making super affordable smart temp/humidity sensors; Ubiquiti has an extensive line of affordable and rugged networking gear to solve internet and WiFi issues as well as a fantastic remote camera lineup; and Monnit offers some of the best rated, affordable, and diverse industrial grade sensors out there currently.

Not all sensors and equipment are created equal. Cheaper means it likely won't stand up to high humidity, extreme heat or cold, dust or years of sunlight. Don't be fooled by a sensor that says it can measure up to 100% humidity either as that doesn't automatically mean it is waterproof.

Also, for digital humidity sensors, above 85% humidity means the accuracy is reduced by as much as 5-7% so don't expect them to help you dial in the humidity to 96% exactly in your root storage area. If you are looking for durability, go for options from Davis, Onset or Monnit that offer the higher industrial grade sensors. Of those three, Monnit will likely come out the least expensive and easiest to use while the other two have more ag-focused offerings.

Most companies have many different lines of products and customizations, so make sure you are choosing the right models for each situation. One of the key points of comparisons is how sensors systems send alerts. Texts, emails, phone calls, push notifications, or auditory alarms are all available, but not by every company.

Forget pen and paper or even spreadsheets. Apps, sensors, robots and controllers all are available to help reduce the need to manually keep records and make compliance easier. New online tools pop up every year for managing some part of your farm. And they don't have to be designed for farms exclusively, Google Docs, Airtable, Mint, Automatic, Google Photos, Time Clock and tons more have great features to do everything from track business mileage, auto organize photos to manage events for either free or small fees.

Now that we've solved a lot of problems, we can talk about the bonus of using more technology: more data, useful information, and text alerts. Winter growing is all about the details. So knowing what the temperature is at plant height in high tunnels compared to the outside temperature becomes critical to ensuring proper growth and yields. And you can check from the comfort of your warm house if you wake up worrying in the middle of the night or while traveling. You may find answers to many questions you didn't know to ask or solutions to problems that never seemed to be solved by watching temperature and monitoring equipment throughout different environments. Furthermore, having data accessible (and in usable formats!) whenever needed saves tons of time and makes running numbers often as easy as tapping a few buttons instead of searching through notes and spreadsheets.

Technology doesn't solve every problem, but, it is a fantastic resource for small, often annoying or time consuming problems that crop up (see what I did there) in the everyday life of farming. With more and more record keeping being required for certifications and compliance, it's worth looking for better ways to track and record data. And sensors and monitoring equipment often return far more in value than most larger investments due to their multi-function nature of preventing disasters, logging data, giving insights, and, of course, just being really cool.

What Works for Organic Disease Control in Winter Tunnels

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Diseases can affect leaves and roots of winter crops. Step 1 in managing diseases of any crop is knowing what diseases can occur and have occurred in the past. Understanding how the pathogens causing these diseases can be dispersed and survive between crops plus conditions favoring their development is critical for developing an integrated management program; pathogens differ in their abilities. Do not rely on using organic fungicides to manage diseases; their use should be last resort as part of an integrated management program. Thorough coverage is particularly important with organic fungicides as most have contact activity and cannot move through leaves as conventional fungicides can. Important to realize that fungicides do not have the capability to cure diseased tissue. Adequately managing diseases affecting leaves of leafy crops is especially difficult because consumers prefer leaves free of symptoms and residues. Situation is different with foliar diseases of fruiting vegetables. Select resistant varieties when available (note that resistance rarely means no disease). Note that some pathogens (notably those causing downy mildew in spinach and lettuce) evolve rapidly generating new races able to overcome resistance. Avoiding bringing pathogens on to a farm is a very important management step. Select seed that has been tested for pathogens that can be seed-borne. Treating seed with hot water or steam kills many seed-borne pathogens; notable exception is those causing downy mildews. Thoroughly clean and disinfect equipment used on another farm, and also in other production areas on your own farm to avoid spreading pathogens. Field plantings of a crop that is also grown in the winter tunnel should be located as far away as possible when susceptible to a pathogen that produces spores dispersed by wind (the mildews), and consider prevailing wind direction; fall planting should be downwind from tunnel. Destroy field planting promptly after final harvest. Avoid favorable conditions. Wet soil is favorable for *Pythium*, a common root rotting pathogen, and slows plant growth especially when also cool. Especially important to avoid wet, cool soils with seedlings because they are more susceptible to root rot. Many foliar pathogens need leaf tissue to be wet for several hours to be able to infect. Therefore it is best to use drip irrigation. When using overhead irrigation with crops under row cover, water in morning so there will be enough time for leaves to dry before putting row cover back on. Downy mildew pathogens can infect when humidity is high for several hours. Powdery mildew pathogens are unique in that they prefer dry conditions. Promote rapid drying in tunnels with fans. Vent high tunnels as often as temperature permits; but realize when open while field-grown crops are present, spores can move inside from an infected crop outside and vice versa. Routinely check plants for disease symptoms. Look in leaf symptoms for signs of fungal pathogens (spores). Hand lens may be necessary. Early morning is the best time to look because foliar fungal pathogens produce spores during nighttime. Seeing spores confirms identification. Remove diseased crop debris when the causal pathogen can survive in it. Promptly clean up after the crop is finished. Physically remove this tissue from tunnels to minimize potential for the pathogen to remain. With white mold (aka lettuce drop) it is well worthwhile to remove diseased plants when first seen because the pathogen produces survival structures (sclerotia) that can survive in soil many years and the pathogen has a very wide host range; as diseased plant tissue breaks down the sclerotia can drop into the soil. Manage weeds inside and around tunnels as some can be alternate hosts for pathogens and also insect pests, and inside they contribute to humidity. Anaerobic soil disinfestation is a method to manage soilborne pathogens in high tunnels. Critical aspect of an integrated management program is that practices are implemented targeting all potential sources of the pathogen. Sowing pathogen-free seed (tested or hot-water treated) will be irrelevant if planted where crop debris or weeds could be harboring the pathogen from previous

disease occurrence, and vice versa. Successful program also has practices focused on the other requirements for disease to develop: susceptible host and favorable environment.

Powdery mildew and downy mildew diseases have been seen developing on leafy vegetables in winter tunnels in the region. These include downy mildew in spinach, lettuce, and kale and powdery mildew in lettuce and kale. Similarities among all of these diseases include that the pathogens produce spores that are dispersed by wind, have very narrow host ranges that could include weeds, and cannot survive in dead crop debris unless they produced their sexual spore type which are thought to be uncommon for most of these. Narrow host range means these diseases are all caused by different pathogens. Downy mildew pathogens infect when leaves are wet or humidity is high for several hours while powdery mildews develop under dry conditions. The downy mildew pathogens can be seed-borne. Role of this source of the pathogen for outbreaks in the region is not known.

An on-line survey conducted with growers in the region about occurrence of the mildew diseases generated valuable information. It was done to determine how important (widespread) they are and to gain knowledge about occurrence that could contribute to understanding pathogen epidemiology in the region, in particular likely sources. Widespread occurrence could suggest pathogen is being dispersed by wind among farms which is less likely with crops in tunnels than open field, especially during winter. Random occurrence could suggest contaminated seed was an important source. Based on the responses received, these mildew diseases are not occurring widely and tend to occur repeatedly on a farm. For example: 8 responded downy mildew occurs on winter lettuce every year (6) or most years (2) while only 2 saw less frequently and 12 reported never having seen. Several people responded saw in more than 1 cropping season (fall, winter, spring). But 2 responded only saw in winter crop. With spinach downy mildew, 2 responded saw it in fall, winter, and spring crops at least 3 times. 14 reported never having; 12 of those grow spinach all 3 seasons. This suggests these pathogens might be surviving on some farms. It is also possible occurrence reflects varieties being grown with those growers who have a disease selecting varieties without effective resistance or purchasing seed harboring a downy mildew pathogen. Occurrence may partly reflect farm-to-farm variation in favorability of conditions. 4 responded they had downy mildew on both lettuce and spinach. The pathogens are different; they do not infect both plants. But high humidity is favorable for both. 9 respondents had only one downy mildew occur on their farm, which could reflect presence of only one pathogen. Similar with powdery mildew: several respondents had powdery mildew on both lettuce and kale. Similar to the downy mildews - different pathogen but similar favorable conditions, which are drier than downy mildews.

Additional information about the mildew diseases plus photographs and results from the survey are at http://vegetablemdonline.ppath.cornell.edu/NewsArticles/winter-greens.html.

Please share information about diseases occurring in your winter crops! Production in winter tunnels is sufficiently new that there are gaps in knowledge, which is needed to identify research and extension needs. Samples of spinach with downy mildew are wanted for race identification to guide variety recommendations.

Labeled organic products for downy mildews include copper, Actinovate, Cease, Double Nickel, LifeGard, Oxidate, Regalia, Serenade, Sonata, Timorex Gold, Trilogy, and Zonix. These are also labeled for powdery mildews with the exception of Zonix. Other fungicides include sulfur, JMS Stylet-oil and other mineral oils, and MilStop and other potassium bicarbonates. Products labeled for root rotting pathogens include Actinovate, Bio-Tam, Double Nickel, Promax, RootShield, Serenade, Taegro and SoilGard.

Please Note: The specific directions on pesticide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Note that some products mentioned are not yet registered for use on cucurbits. Check labels for use restrictions. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.

What Works for Organic Insect Control in Winter Tunnels?

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Many Northeast vegetable growers find winter high tunnels an excellent way to produce 'off-season' greens with little-to-no fossil fuel based heat. These production systems contribute to economic and social sustainability by creating year-round income and maintaining customer relations during the traditional off-season.

However, pest infestations, such as aphids, mites and cabbage worms restrict the economic potential of these systems. As an experienced grower put it- "Pest management is so much more important in the winter because your losses are so much more".

This quote illustrates an important concept in 'winter' pest management. Crops are growing slowly and somewhat unpredictably. As fall weather varies, temperature and light intensity play a greater role in total crop biomass than in warmer seasons. A cool, cloudy fall can severely delay crop growth.

As plants slowly respond to decreasing light however, residual insect pest levels are still at high levels from the warm season. With less outdoor crops for these pests, high tunnels can soon develop an imbalance in crop canopy and pest levels. A young planting of Asian greens can quickly be overtaken by cabbage worms who've run out of cabbage in the field.

The decreasing day length and temperature also effect 'what works' for organic insect control. For worm pests, Bt products such as Dipel have a greenhouse-approved label and are OMRI listed. These Bt's can work quite well, but as a stomach poison, are dependent on temperature driving the feeding and metabolism of the target pests. They must be used early in the production cycle to work well.

Appropriate planting density can also help with insect (and disease) control. High density planting interferes with insect management by making it hard for OMRI materials to reach the target. This illustrates a key difference between stomach poisons and contact sprays. For example, aphid materials such as Mycotrol, require contact with the insect for the microbial agent (*Beauveria bassiana*) to infect the insect body. When the greens canopy is closed our sprays cannot effectively reach the target.

Once we move into the colder months where days are shorter and freezes common, spraying no longer makes sense as we can damage the foliage. Can we use biocontrols?

For pest control in warm season tunnels, biocontrols such as predators and parasitoids are an excellent option. However, as temperatures drop we refrain from the release of biocontrols, with one exception: lady beetles. Under row covers lady beetles have provided excellent control of aphids at some of our cooperating sites (Figure 2). The row cover keeps these predators where we want them, and also provide some temperature protection which likely increases their

activity. Note that our experience shows aphids overwinter very well in unheated high tunnels. So if you have a history of aphids, it would be wise to have lady beetles on hand prior to a rapid population spike.

Winter growing in the Northeast is more accurately described as Fall growing and winter harvesting. Pest management follows the same pattern. Controlling pests such as aphids and cabbage worms in the fall will lead to a healthy crop for winter harvests. In the fall we have multiple OMRI spray options, and pest metabolism and canopy temperature facilitate the use of these products. Due to our short day lengths and low temperatures our biocontrol options are very limited, making the Fall pest control that much more important.

Figure 1 Winter crop canopy is often at a severe disadvantage to hold-over full blown pest populations.

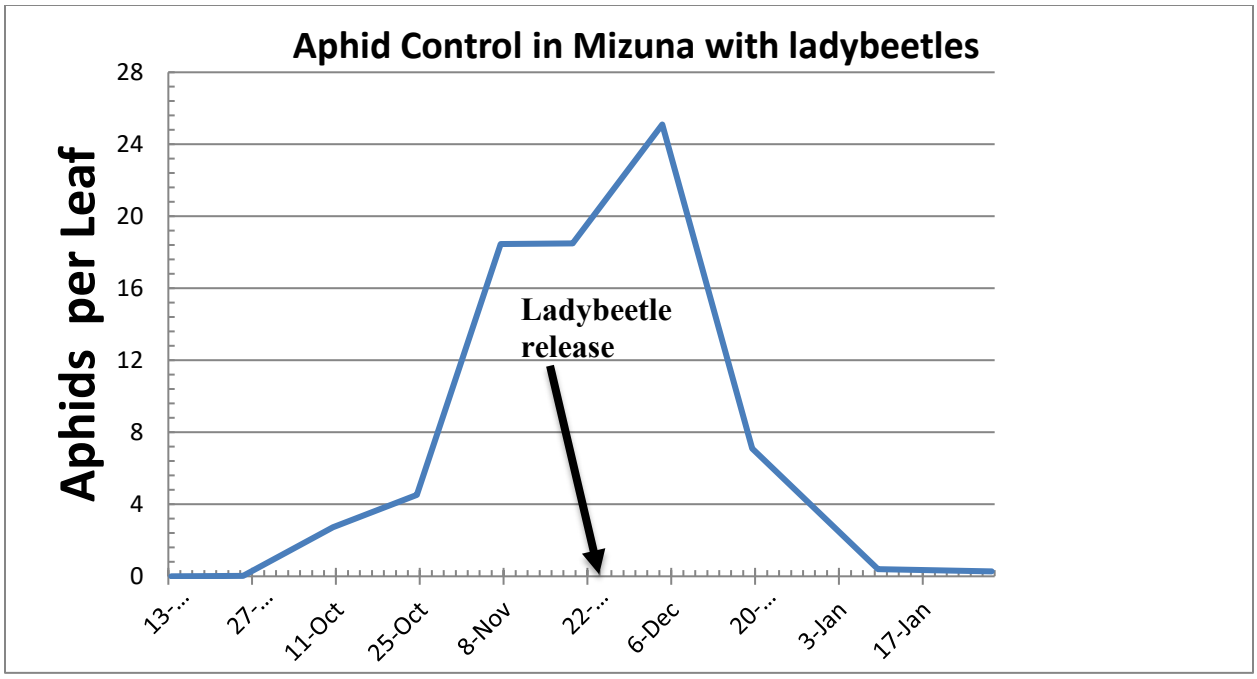

Figure 2 Lady beetles can be effective for aphid control in winter tunnels, particularly if row cover is used to restrict them to the crop canopy.

Figure 3. Lady beetle larvae foraging in a high tunnel crop.

Production of Overwintered Onions: Bed Prep by Steaming; Varieties, Techniques, and Economics

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Now entering into our 32nd year, Pleasant Valley Farm, located in zone 4 of upstate NY, and has been the pioneer in experimenting and raising onions year-round for the past 9 years. Onions are an item our customers want to have every week, so we work to have them available as many months as possible. The key to doing this is to grow onions all winter and have them ready to harvest from late May until the regular summer onions are ready in July, and often into the late autumn.

Onions are seeded in the greenhouse in late August or the first week September. Successive plantings are ideal if one has the time and ability. The varieties we like are Keepsake and Hi-Keeper, Walla-Walla, and Electric (red), but we are trying some new varieties most every year since some types disappear. With Electric unavailable this winter, we are trialing Red Spring. In the greenhouse, we seed 2 seeds per cell in 162 Winstrip trays or seed into 16x13x2" nursery trays with 9 rows that each have 30 seeds per row. We use the biologicals Root Shield Plus and Actinovate to prevent diseases by drenching the trays in the greenhouse. The dates of seeding are tricky as we never know the weather. If you seed and plant too early, they are more susceptible to bolting in the spring, and if planted too late, they do not size up as well, so yield is reduced. New varieties are helping resolve some of that!

We fertilize pre-plant for what is needed after running a fall soil test, making sure we have all the micronutrients in balance, in addition to NPK. For Nitrogen, we shoot to add about 75# of Nitrogen per acre of organic fertilizer and it's important to choose an area to plant that is weed-free, especially no winter weeds like chickweed. After working the soils with chisel plow and tiller, raised beds are formed for outside production, and no beds on the inside of the tunnel.

We have been steaming some tunnel soils for several years to eliminate weed seeds, as well as helping with disease control. This is done using an older steamer (boiler), with a "sock" that runs down the bed under a tarp, and which has heavy chain going around the perimeter of the tarp to seal in the steam. It takes about 1 hour per 75' bed for the boiler to get the soil to 160 degrees, our goal to destroy weed seeds; it only heats the top couple of inches, but it very effective. The boiler uses about 3 gallons per hour of fuel oil. The cost of steaming the soils is far cheaper than hand weeding/cultivating.

We transplant our onions out in late October or the first week of November, when they are rooted well. We typically do not trim the tops, but will if they are too tall. All are planted as single plants (we split the doubles as we plant). We plant all on a 6"x6" grid system, half in a low (7' high) tunnel that is 14'x100' with 23 rows in it (4600 plants total). We now do raised beds outside the low tunnel and plant 5 rows per bed. Keeping them all watered well is important after planting, and then in November, we cover both with row cover (one layer P30 inside; or

outside, we often use Typar for deer control). The tops will get bent over which is no problem. Plastic mulch is an option we tried one year and it did not work great due to limiting the water penetration since the onions grew and covered the holes, and drip irrigation is not an option in the winter. For the most part, watering is not necessary in mid-winter, and our overhead irrigation line in the tunnel works great in the spring.

Forum onions have been a key part of our over-wintered onion crop, and they are sold as an onion set through Johnny's Selected Seeds. There have been changes in their cropping over the years, but now are available in bags of 1000 with a fairly uniform size; however, we noticed that the size of the bulb does not affect yield/bulb size. Forum onions are a deep golden color, and semi-sweet in flavor, and also easily store for 5-6 months.

In Spring, we fertilize to add approximately 100# Nitrogen per acre as soon as the ground can be worked, typically with Chilean Nitrate. The onions are cultivated as necessary, vented, and irrigated starting in early March; Irrigation increases as they onions grow faster in April and May. We are careful with the onion tops during cultivation (all done by hand with small wire-weeders). Row-covers are removed daily when possible and thrown back on if very cold nights.

In late May, the onions in the tunnel are ready to harvest…Yellow varieties like Keepsake or Hi-Keeper are ready first, then the Forum sets, then the reds (Electric) and Walla-Walla. The onions out on bare ground are ready 3-4 weeks later. They all can be fresh-harvested or dried down and stored for many months. In June, we start monitoring for thrips, as they could start to come in, which does not affect the overwintered onions very much, but can be a real problem for the summer/fall onions. Separating the two groups on the farm for planting beds is important.

In 2019, there was no bolting of onions at all, but in other years, we have seen a lot of bolting. Bolting onions can be pulled early and still are usable, more like a large scallion. We sometimes plant the Forum onion sets close together (2") and harvest then as scallions in the spring. As the varieties improve, and more research has been done on the dates, we see less bolting.

These onions give a great return to and we have had great success with them for most years. The small tunnel holds 4600 onion plants and the onions are sold in the range of $1.50 to $2 each, which extrapolates to over $8000 per tunnel (1400 Square feet)! That calculates out to almost $250,000 per acre! These onions are a welcome sight in May/June and they can be big and beautiful… and customers love them.

Strategies for Weed Control in Brambles

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Managing weeds is a fundamental requirement of growing brambles successfully. Without weed management, attempts at nutrient management and integrated pest management are obstructed, harvesting is difficult, and yields are depressed. Weed management is particularly important in the planting year, for if the berry plants establish well, then weeds are easier to exclude and manage in subsequent years.

Growers should take a three-pronged approach to managing weeds: eliminate weeds prior to planting; prevent them from establishing; and eliminate them once they appear.

Eliminate weeds prior to planting

A combination of approaches is required to eliminate or suppress weeds prior to planting. Before the plants are in the ground, you can deep plow, disc, incorporate cover crops, and use herbicides like Roundup to eliminate perennials. This process can take a year or more. Once berry plants are planted, these effective tools cannot be used. For example, there are no herbicides that will remove all established perennial weeds in the row without hurting the berry plants. Eliminating perennial weeds prior to planting is a very critical step. Of course, you really can't completely eliminate weeds, but you can suppress them significantly.

A broad-spectrum, postemergent systemic herbicide can reduce the number of perennial weeds in a field, especially if it is applied the year before planting. Growers generally find that two applications work best – one applied in late spring, then another applied in late summer of the year prior to planting. Applying the herbicide too early in spring could result in missing late-emerging perennial weeds, such as thistle, bindweed and nutsedge.

Preplant cover crops will compete with emerging weeds, provided they do not produce seeds themselves (i.e. buckwheat will reseed if not plowed in at the right time). Many cover crops are available that can be grown the year prior to berries to suppress weeds and to add organic matter to the soil. Sudangrass has a suppressive effect on nematodes, buckwheat and rye suppress weeds, and cover crop rotations can reduce disease inoculum. Cover crops that are unrelated to berries (such as grasses and grains) usually make the best rotational companionsp; herbicides can be used on these that are not labeled for the bramble crop.

Fumigation also can reduce the weed seed bank prior to planting, but this option is expensive and rarely used. If fumigation is used, soil should be in a condition that will promote weed seed germination (that is, finely cultivated and moist) and should not contain plant residue.

Prevent weeds from establishing

Perimeter weeds can serve as a significant source of weed seeds. Mow the perimeters of the berry fields as one would a lawn to keep weeds from flowering and going to seed. Flowering weeds can host tarnished plant bugs and other berry pests, and attract pollinators away from the berry flowers.

Maintain a weed-free zone of about 3 feet in the row under the plants. Mulches can be used to suppress weeds around plants once they are planted in spring. There are several choices and each has advantages and disadvantages.

- Straw mulch: This mulch performs very well for tissue-cultured plants. It provides a desirable environment for roots to establish and eliminates the need for cultivation that damages shallow plant roots. Straw mulch should be allowed to decompose by the end of the growing season. Persistent straw mulch will create conditions favorable for root rot.

- Plastic mulch: This mulch suppresses most weeds and raspberry roots grow well under it. The disadvantage is that it has to be removed at the end of the season to allow new primocanes to emerge the following spring. Black plastic mulch warms the soils and this is favorable for raspberry root establishment.

- Landscape fabric: This mulch is intended to provide a permanent weed barrier in the row. Generally some open space is required for primocanes to emerge near the plant. Thornless blackberries and black raspberries do not produce buds along their roots, so landscape fabric works well for them. It allows water to penetrate yet prevents most weeds from emerging. It works less well for red raspberries since primocanes emerge along the entire length of row. Some weeding is still required near the base of plants and it is more expensive than other mulches. But given that the need for herbicide is eliminated, some consider it worth the cost. A second option is to put down two parallel rows of landscape fabric, allowing a narrow band of 12 inches between them for primocanes to emerge.

Herbicides are available that suppress weed seed germination. These are best applied in the late fall or early spring – not during the growing season. Attempting to kill weeds in the raspberry row with herbicides during the growing season is risky. Raspberries and blackberries are sensitive to most postemergent herbicides and are sensitive to preemergent herbicides when plants are young.

By seeding grass in the alleyways, growers can easily manage the vegetation with mowing. These grasses will keep weeds from establishing. Perennial ryegrass, a non-creeping fescue, or a combination of these, work well. The advantage of a grass alleyway is that it reduces mud and compaction, and allows pickers onto the field shortly after a rain. A vegetation cover also improves the accessibility for equipment and people and reduces the erosion potential. Covers use excess water so that field operations are not hampered following rain, they limit soil compaction from machinery, contribute to organic matter and help stabilize erodable soils. A seeded cover crop also can displace weeds (with known undesirable traits) that would otherwise

occupy the niche. Competitively displacing weeds with a more desirable species is better than allowing weeds to dominate or destroying soil structure through repeated mechanized cultivation. The primary drawback of cover crops is that they can compete with bramble plants for nitrogen and moisture.

Do not apply straw to the row middles as this will keep roots too moist and create conditions favorable for Phytophthora root rot

Eliminate weeds when they appear

When weeds do appear in the row during the growing season, some hand-weeding will be unavoidable. Remove perennial weeds by hand as soon as they appear so they do not establish in the planting. Once perennial weeds establish in a bramble planting, they are hard to eliminate.

Cultivation is useful to a limited extent, but raspberries and blackberries have shallow roots. Damaging them can affect future cane production. Furthermore, cultivation that damages roots can increase the susceptibility of berry plants to disease. Cultivation promotes further weed seed germination, degrades soil quality, and can disturb the shallow root system. It can dilute any herbicide that was applied previously and can bring new weed seeds to the soil surface where they can germinate. It is best to avoid regular cultivation if other methods are available.

There are few specific herbicides that kill established weeds but do not harm bramble plants. Post-emergent grass herbicides are safe to use. Other herbicides may be safe to use around floricanes, but the more sensitive primocanes will be damaged. All of these caveats point back to the need for preventative management rather than trying to treat weeds once they have established.

Bramble Plant Nutrition: High Tunnel vs. Field

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Nutrition and fertilization are important components of the overall management of a berry planting. It is difficult to get accurate nutritional recommendations for a particular farm because many factors influence nutrient uptake and availability. For example, pH, moisture, organic matter content, clay content, and mineral composition of the soil all strongly influence nutrient availability. Management practices such as tillage, irrigation, herbicide use, and fertilization history also affect the plant's ability to take up nutrients. Weather plays a role: conditions that reduce transpiration may cause temporary nutrient deficiencies. In recent years, growers have been planting brambles under tunnels. Tunnels alter rainfall and temperature, further complicating the management of nutrients. Since all of these factors interact to affect nutrient uptake and since these factors differ from farm to farm, it is difficult to provide precise recommendations.

The topic of nutrient management is extensive, so the reader is referred to http://www.hort.cornell.edu/fruit/berry-guides/bramble.pdf for principles and detailed information on nutrient management. Tunnel growers should view http://www.hort.cornell.edu/fruit/pdfs/high-tunnel-brambles.pdf for the latest information on berry production in this system.

Soil Preparation

Field: At least a year prior to planting, the field should be prepped. This involves installing drainage if necessary, soil testing, pH adjustment, weed suppression and the incorporation of organic matter to the extent possible. Depending on the results of the soil test, amendments may be recommended.

Soil pH is the most important factor affecting the availability and uptake of plant nutrients. Some nutrients become more available at a low pH, others at a high pH, and others between pH extremes. At a soil pH of 6.0 to 6.5, all essential nutrients are potentially available to the plant, so this is the recommended target for pH adjustment.

Tunnel: The same procedures apply. However, the opportunity to incorporate organic matter into the soil of a high tunnel after planting is quite limited. Furthermore, the dry conditions in the tunnel decrease microbial life. Plants perform better if the organic matter level in the tunnel is high before planting. We recommend significant compost incorporation provided that it is low in salts.

Irrigation

Field: Drip irrigation is the water delivery method of choice by most growers. Drip tape applies water evenly and efficiently and does not wet the foliage or fruit. Overhead irrigation is still used by some growers who already have the equipment in hand.

Tunnel: Drip irrigation is essential in a high tunnel as the cover prevents rain from getting inside. While tunnels increase yield and reduce disease, they require good water monitoring practices to prevent drought stress. During hot days, plant water use can be quite high in a tunnel.

Fertilization

Field: Nutrients are applied in the field as granular particles that are broadcast in the row or across the field. Fertigation is also an option for field-grown brambles, but is mostly used to complement dry fertilizers rather than replace them completely.

Tunnel: Drip irrigation/fertigation is essential for applying nutrients in a tunnel. Broadcast fertilizers will not "wash in" since there is no rain in the tunnel. Therefore, regular (weekly) applications of fertilizer are necessary for adequate plant growth.

Nitrogen

Field: Depending on the type and age of bramble, N rates range from 25 – 100 lbs. actual N per year. The higher amounts are for fall-bearing plantings that are three-years-old. Split applications are best for the plant e.g. half at bud break and half 6 weeks later. A second option is to apply the second half through the irrigation system over the summer months.

Tunnel: Applications of N will occur exclusively through the irrigation system. The amount to apply will depend on many of the factors mentioned earlier, but a good starting point is 200 ppm N at least once a week (up to every watering). This rate does not convert to a lbs/acre rate so ppm is used instead.

Other nutrients

Field: Following the **s**oil test recommendations with proper pH adjustment prior to planting should create an environment that promotes adequate nutrient uptake. Leaf analysis is used to make adjustments to the fertilizer program. Recommendations are based on newly expanded leaves collected in mid-summer, usually the first week of August. Other sampling times or plant parts may prove to be more appropriate for certain nutrients; but until more detailed studies are done, foliar samples collected in midsummer are the standard.

Tunnel: It is best to assume that no nutrient (except for perhaps phosphorus) is available in sufficient quantities from tunnel soil, so a complete fertilizer solution should be used from the beginning. After the plants have grown for several months, adjustments can be made to the rates and fertilizer type. For example, when plants fruit, they may require extra potassium so additional potassium sulfate can be added to the fertilizer solution. Conversely, some nutrients

may be too high with a complete fertilizer so adjustments can be made in the rate. For example, some of the N can be provided by calcium nitrate while the concentration of complete fertilizer is reduced. Chelated micronutrients and boron are easy to add to the fertilizer solution.

A foliar analysis is the only way to know if the fertility program is on target. Several tests per year may be required if the plants are not performing as expected. After some experience, frequent testing may not be necessary.

Salt accumulation

Field: Typically, plantings in the field rarely suffer from salt build-up. Exceptions would be when high rates of fertilizer are used, when the fertilizer has a high salt index, or when high rates of certain composts are applied. The amount of rainfall in the Northeast usually leaches salt out of the soil so these ions do not accumulate.

Tunnel: Salt accumulation is a very real concern in a tunnel. The higher temperatures cause evaporation, leaving salt residues behind. The lack of rainfall in a tunnel means that leaching cannot occur unless the covering is removed. Some growers remove the plastic covering after plants go dormant so salts can leach during the winter. This requires recovering in the spring and some cultivars may be too sensitive to tolerate uncovered conditions during the winter. We also recommend compost amendment prior to planting. Some composts have a high salt content so should not be used in a tunnel. Also, water itself can be salty if drawn from a well. Ideally water should start with only 1 mS, or 2.0 at the most.

Sufficiency ranges for foliar nutrient levels in raspberry leaves in midsummer.

Nutrient	Deficient Below	Sufficient	Excess
N (%)	1.9	2.0 – 3.0	4.0
P (%)	0.20	0.25 – 0.40	0.50
K (%)	1.3	1.5 – 2.5	3.5
Ca (%)	0.5	0.6 – 2.0	2.5
Mg (%)	0.25	0.6 – 0.9	1.0
S (%)	0.35	0.4 – 0.6	0.8
B (ppm)	23	30 – 70	90
Fe (ppm)	40	60 – 250	350
Mn (ppm)	35	50 – 200	350
Cu (ppm)	3	6 – 20	30
Zn (ppm)	10	20 – 50	80

SWD Netting: Will it Really Work for PYO?

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We have now used ExcludeNet 80 gram netting for SWD management on our raspberry high tunnel (30' x 144') for three years. We cover the side walls and end openings with the 80 gram ExcludeNet and have a double door entry way with zippered doorways. We have had less than 2% infestation from SWD during that time.

In 2017, we had a few raspberries ripen before we completed our netting installation. On July 22nd, I put one huge, beautiful, FIRM raspberry in a cup of salt solution (1 Tablespoon salt in 1 cup of water). That one firm raspberry yielded 22 small SWD larvae. Because I had verification that SWD had found the very few fruit that were in the tunnel, I pruned out any floricane fruit that had formed, harvested the few primocane fruit that were starting to show color, made one application of spinosad, and then closed up the ends of the tunnel and added our double door entryway. I never sprayed again for the rest of the season. Raspberry fruit samples were collected weekly by Laura McDermott of Cornell Cooperative Extension and sent to Greg Loeb's lab at Cornell Agri-Tech in Geneva where they were put in salt solution to determine infestation levels. We harvested for 15 weeks in 2017 and had a total of 1.2% infestation over the 15 weeks.

In 2018, we closed in the ends of the tunnel during the third week of July and monitored with SWD traps. We once again had a few floricane fruit that escaped our notice until they were ripe –this time on July 23rd. We again removed all floricanes with fruit on them. Rather than spray with spinosad at that point, we had some "Attract and Kill" traps left from a previous year that we deployed. We also purchased and deployed 8 commercial Scentry SWD traps and lures that we purchased from Great Lakes IPM. Weekly fruit collections were again made by Laura and sent to Greg Loeb's lab. The SWD traps were checked weekly. We were able to keep populations in check for the month of August. In early September, we ran into conditions that are absolutely ideal for SWD – 80 degree days, 70 degree nights, and humid, with several days of that type of weather forecast. Samples from September 4th showed that we had slightly exceeded my personal threshold of 5% infestation so I made an application of spinosad. One small larvae was found in samples collected on September 11th, and then no more larvae were found for the rest of the season. We collected our last samples on October 9th and included some berries that were outside the tunnel and never sprayed. On October 9th, 15 berries from outside the tunnel had 18 SWD larvae. On October 2nd, 4 berries collected outside the tunnel had 18 larvae. We harvested until November 8th in 2018 – a 17 week season with a total of 1.9% infestation for the season.

80 gram ExcludeNet netting, carefully installed on a high tunnel structure, with a double door zippered entryway clearly works to exclude SWD. It has worked for six years on my commercial blueberry planting and three years on my high tunnel raspberries (Photos 1 and 2). Many people have said that Pick Your Own customers will not accept it. Like so much in life, it comes down

to how you market it. A blueberry grower in VT has covered his small-scale blueberries with the netting and Pick Your Own customers loved it. One even exclaimed, “You could hold weddings in here!” In 2019, for the first time, we had limited pick your own in our covered blueberry planting. We had about 50 parties (ranging from 1-6 people/party) picking in the planting. I did about a 60 second educational session on SWD and the netting, and explained the importance of closing the zippers on the doorways. Every single customer thought it was a great experience; not a single person had anything negative to say. Common phrases were “it’s so serene in there” (also stated in the VT blueberry planting), “this is the coolest place I have ever done pick your own”, “thank you for figuring out a way for us to have no-spray berries” and “this is blueberry paradise”. There is no reason that pick your own customers in raspberries cannot have the same experience.

A team of us from the Northeast is hoping to obtain funding to create a set of plans and list of materials that growers can use to build their own support structures for using exclusion netting. If funded, we also plan to create YouTube videos to explain the different parts of the construction process and covering the structure with netting. Grower ingenuity with support structures is happening throughout the east. I end my talk with showing photos of examples of structures that growers are using to support the netting.

SWD is a problem that is here to stay. Any possible biological control agent is at least 15 years away, and that will not offer complete control. Netting is available now, has been proven to work and provide control better than any weekly insecticide application, and is easy to use. Timing is everything (installing the netting before SWD appears), and with attention to detail in construction and maintenance, can result in a great crop of virtually SWD-free raspberries.

Photo 1. SWD infestation data and Blueberry Yields at The Berry Patch.

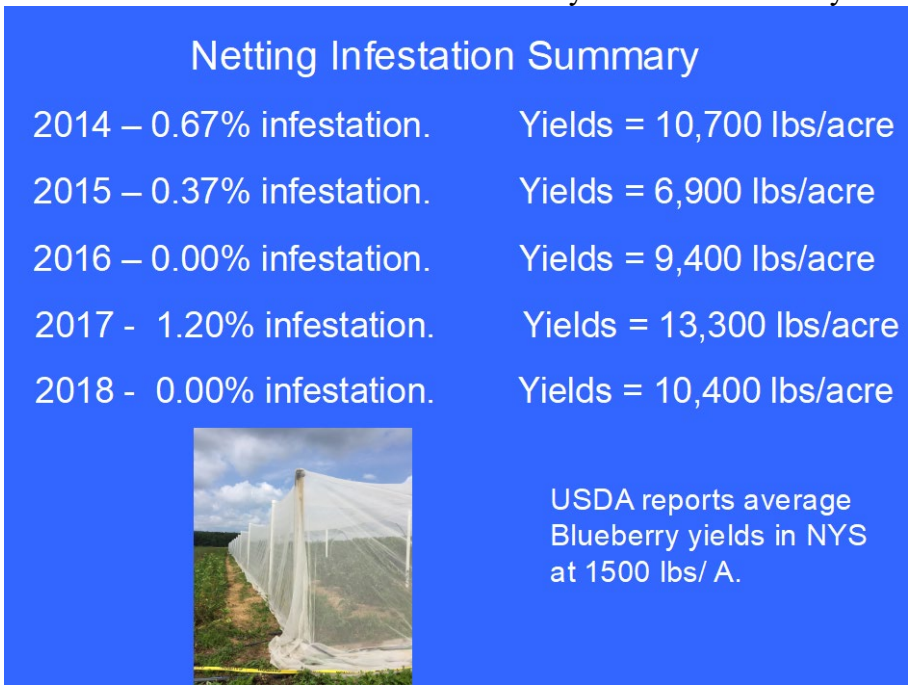
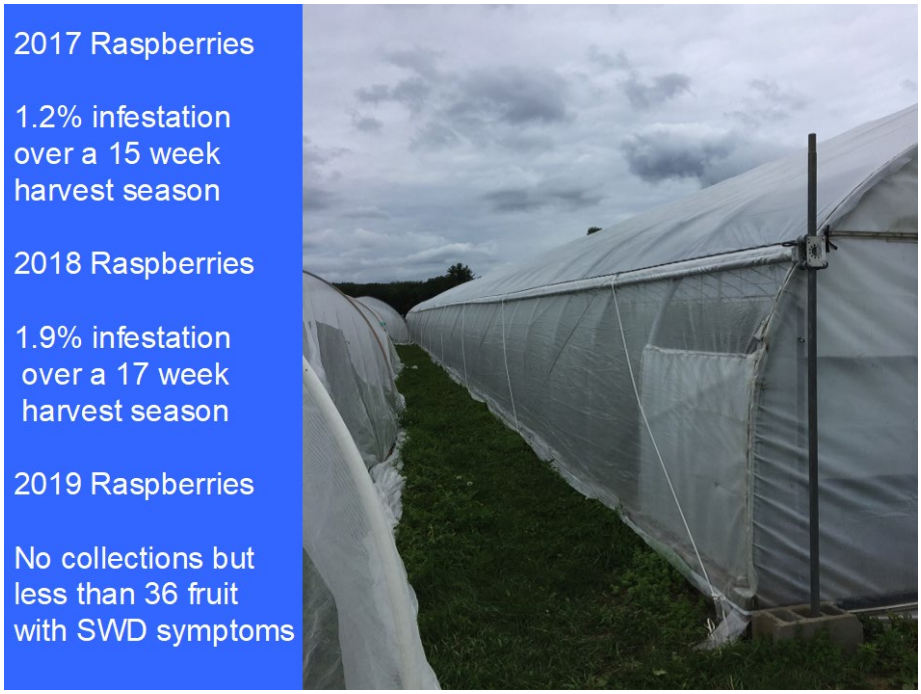


Photo 2. SWD Infestation rates in high tunnel raspberries at The Berry Patch.



Sprayer Plant Relationship to Coverage & Calibration

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

Proper calibration of sprayer equipment is the only way to ensure spray applications are effective, efficient, and economical. Poor spray coverage is the primary cause of reduced spray product performance. Regular care and maintenance will ensure the sprayer is residue-free and serviceable when needed.

A sprayer should never be operated without first checking the calibration for the following reasons:
1. To determine the precise rate of material applied per acre.
2. To ensure each nozzle tip is operating at the manufacturer's specification.
3. To compensate for equipment changes, crop staging, and environmental conditions.

Calibration Factors Affecting Application Rate

- Ground Speed - A uniform ground speed is necessary to maintain even spray application. The spray application per acre varies inversely with the ground speed of the sprayer. If the ground speed is doubled the application rate is cut in half and as the ground speed is reduced to half, the spray application is doubled. Rate controllers can only compensate for this within certain limits and can sometimes have a negative impact on spray quality.

- Nozzle Flow Rate - The flow rate through the nozzle varies with the tip size, the pressure applied, and the condition of the tip.

Spray Deposition

Before checking the spray pattern, check your sprayer and all of 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. Test the sprayer at the same speed (RPM, gear and throttle setting) you plan on using when treating your intended crop or area. Put clean water in the tank when testing.

The air blast sprayer's nozzle orientation affects the spray pattern that's emitted. Traditionally, nozzles are positioned radially around the sprayer's air outlet. On a counter-clockwise 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.

Use water sensitive cards to determine spray pattern or deposition. These are available from some pesticide suppliers and many spray equipment dealers. Each card is used one time. They are yellow, and where a drop of water or oil touches the card, that spot turns blue. Set up a series of cards on the crop you intend to spray. For an orchard or small fruit planting, set cards at the top of the canopy (on a pole, for example), in the interior and low in the canopy. It is helpful to mark the position on each

card with a pen. You can use clothespins to clip them onto the plants. Run the sprayer once by the row or block, then retrieve the cards to see your coverage.

Kaolin-clay based-sprays like Surround or dyes in the sprayer tank can also make spray deposition patterns visible. If you are spraying a crop, be sure you use food-grade materials approved for the crop. This quick method makes it easy to visualize gaps and overlaps in some cases. Wait a few minutes for material to dry before checking results. Often the material will wash off with the next rain.

A vertical patternator is used to simulate the canopy. It is placed at the end of the row, in-line with the trees or plants. The sprayer is stationary. Turn on the sprayer and spray clean water out of the nozzles, with the fan turned on. As you test, select different nozzle configurations (number and orientation). Water is collected in the graduated cylinders. The results show the vertical distribution pattern.

Results from the patternator show great variability in spray pattern produced according to nozzle orientation and which side of the sprayer they are on. Remember, the rotation of the sprayer air can affect spray coverage.

Vertical spray patternators are used in Europe for inspecting and calibrating air blast sprayers. However, little information is available about their reliability, particularly when used for crop-specific calibration. Vertical spray patternators can aid in adjusting nozzle position and orientation if changes are made according to fruit canopy size and geometry.

Sprayer Maintenance

The following practices will prolong the life of the sprayer:

1. Remove the nozzles and strainers. Flush with clean water at the end of each day of use, if not more often.
2. Use a soft brush or a can of compressed air when cleaning.
3. Never apply corrosive fertilizer solutions through an air blast sprayer.
4. Remove and clean strainers after completing the spray application, or when products change on sequential applications, whichever comes first.

Nozzle wear occurs most rapidly when wettable powders, flowables, or dispersible granules are applied, especially at high nozzle pressures. Under these situations, the tips and cores on the nozzles should be manufactured from hard, wear resistant materials. Abrasion-resistant nozzle components cost more initially but are quite cost effective in the long term.

Calibration Notes

Recording your sprayer calibration calculations for future use is important. By maintaining a record, you can compare your calculations from calibration to calibration. Recordkeeping is also due-diligence and is important to have should questions arise about product residue, pesticide drift or other spray complaints.

High Tunnel Eggplants: Varieties, Pruning & Post-Harvest Storage

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Introduction. Recently, parthenocarpic varieties of eggplant (ones that set fruit without pollination) have been developed specifically for GH and tunnel production. In other parts of the world where GH eggplant is more frequently grown, various pruning systems are used to enhance productivity and growth. Our primary objective was to compare *yields of eggplant varieties* in high tunnel production conditions. We specifically chose to focus on elongated Italian types and to include new parthenocarpic varieties. We had two additional objectives: 1) to determine whether *pruning to 2- or 4-leader systems would affect yields* compared to no pruning, and 2) to compare quality of different varieties in *post-harvest storage*.

In 2018 and 2019, eggplants were seeded on 12 Apr 2018 and 25 Mar 2019, and transplants were moved into the high tunnel on 1 Jun 2018 and 20 May 2019. We applied soybean meal (7-1-2) and potassium sulfate (0-0-50) preplant to provide 55 lb/A of N and 145 lbs/A of K_2O. Planting beds were spaced 4' on centers, slightly raised (1-2"), covered with embossed black plastic mulch. For the variety experiment, plants were spaced 12" apart in single rows. In 2018, Azera (pyrthrins, neem) was applied on 27 Jun 2018 to control aphids, and Shuttle-O (acequinocyl) was applied once on 10 Aug to control spider mites. In 2019, Shuttle-O was applied once on 16 Aug to control spider mites.

Data collected. We harvested eggplants weekly between 6 July and 18 Oct in 2018, and between 3 July and 18 Oct in 2019, when plants were killed by frost – nearly 15 weeks. Fruit were counted, weighed, and sorted into marketable and unmarketable (scarred or misshapen). On two dates in each year, harvested fruit were set aside for postharvest experiments.

Results. Eggplants produced over 6 lbs of fruit per plant during the season for some varieties. They produced marketable fruit very early; we harvested the first fruit just five weeks after transplant. All varieties showed a good continuity of production, aside from a dip in early September. This may have been at least in part due to a spider mite infestation in August. Plants continued to produce marketable fruit until experiments were terminated in mid-October.

Variety performance. There were *only slight differences* in total marketable yield between varieties (see table, below) in 2018, and *no significant* differences in 2019. In 2018, the white variety **White Star** had significantly lower yields compared with **Nadia** and **Angela**. **White Star** also had a significantly lower percentage of fruit that were marketable (69%) than other varieties, largely due to scarred and/or misshapen fruit.

Table 1. Marketable yield for ten eggplant varieties grown in the high tunnel in Durham, NH.

			Marketable Yield			
			2018		2019	
Type	Variety	Fruit Color	Wt (lbs) per plant	% marketable fruit	Wt (lbs) per plant	% marketable fruit
GH	Angela	Striped	6.1 a	94 a	6.4	99
GH	Annina	Striped			6.7	100
GH	Aretussa	White	4.7 ab	86 a	6.2	94
GH	Jaylo	Purple	5.0 ab	87 a	5.4	94
GH	Michal	Purple	5.1 ab	84 a	6.0	99
field	Nadia	Purple	6.3 a	91 a	6.8	96
field	Nubia	Striped			6.0	100
field	Traviata	Purple	5.8 ab	88 a	6.8	97
GH	Tucci	Purple			4.9	95
field	White Star	White	3.5 b	69 b		

Seed sources: Angela, Aretussa, Jaylo, Nadia, Nubia: Johnny's Selected Seeds; Annina, Michal, Traviata: High Mowing Seeds; Tucci: New England Seeds; Annina, Traviata, White Star: Harris Seeds

Of the two white varieties, **Aretussa** was very uniform, whereas **White Star** (2018 only) was much more variable, with several plants that produced light-green off-type fruit. Of the purple varieties, **Traviata** and **Jaylo** had distinctly pear-shaped fruit, whereas **Nadia** and **Michal** fruit were more elongated. **Tucci** (added in 2019) fruit were very slender, more Asian than Italian type. **Jaylo** was a lighter purple color, with many of the fruit showing pale purple stripes near the base of the fruit. **Angela, Annina and Nubia** all produced uniform elongated striped fruit.

Support & Pruning Systems. In 2018, we compared three pruning systems (2-leader, 4-leader and corralled) for three varieties (Michal, Nadia, Traviata), and in 2019, we compared just two systems (4-leader vs. corralled). The variety trial was corralled in both years. In our 2018 preliminary pruning experiment (two replicates only), the 4-leader system producing higher yields than the unpruned system. In our larger 2019 experiment, **we did not observe differences in yield between the pruned vs. unpruned treatments**.

Table 2. Marketable yield and frequency of marketable fruit for three eggplant varieties (Michal, Nadia, and Traviata) grown in three different pruning systems.

	2018		2019	
Pruning Treatment	No. fruit per linear ft.	Wt (lbs) per linear ft.	No. fruit per linear ft.	Wt (lbs) per linear ft.
Unpruned (corralled), 12" spacing	9 b	5.7 b	9.6	6.5
Four leaders, 12" spacing	12 a	7.8 a	9.0	6.1
Two leaders, 6" spacing	11 ab	6.7 ab		

Postharvest Storage. The ideal storage conditions for eggplant are 10-12°C (50-54°F) and 90-95% relative humidity (USDA Handbook 66). Eggplant fruit are particularly sensitive to dessication and weight loss at temperatures above this range, and to chilling injury at temperatures below this range. In four experiments, we held eggplants at different temperatures for two weeks to determine whether varieties may be more or less susceptible to these postharvest problems.

Table 3. Postharvest storage conditions in 2018 eggplant experiments.

Our Postharvest Storage Conditions	**Extreme Temperatures**		**Temperature (°F)**	**Relative Humidity (%)**	
	Max (°F)	Min (°F)	**Average ± SD**	**Average ± SD**	
Packhouse	63.3	79.4	73.1 ± 2.3	76.1 ± 6.6	*too warm*
Cooler	60.0	64.3	62.5 ± 0.9	90.1 ± 3.5	*close to ideal*
Refrigerator	38.2	47.4	42.2 ± 2.0	96.6 ± 3.5	*too cold*

Our results clearly illustrated the problems caused by storing eggplant at temperatures that are too cold or too warm. At temperatures that were much too warm (e.g. the packhouse), eggplant fruit lost much more weight and softened much more than if stored at cooler temperatures. At cold (refrigerator) temperatures, eggplant lost the least weight and remained very firm, but they suffered chilling injury, showing surface pitting and browing. Several varieties also exhibited mold on their calyxes after two weeks storage; this was more evident at the higher temperatures than in the refrigerator.

In 2018, varieties differed in susceptibility to these problems. **Angela** lost significantly less weight and remained significantly firmer than some varieties (e.g. **Aretussa** and **Michal**). Along with **Jaylo** and **Traviata**, **Angela** also showed the least browning after two weeks' storage; **Aretussa**, **Michal** and **White Star** showed the most browning.

Take-home messages & future directions.

- We were impressed by the early, prolific, and prolonged fruit production of high tunnel eggplant varieties. Cumulative yields exceeded 6 lbs per plant (1.5 lbs/square foot) in some cases; we suspect that with even earlier planting, this could likely be increased.

- Challenges associated with high tunnel eggplant production include attractiveness to **aphids** and **spider mites**; growers should monitor frequently for these pests, and have a plan in place to manage them if they are detected.

- While the typical field strategy of corralling plants without pruning produced acceptable yields, pruning the plants to **four leaders increased yields** in **one year** for the varieties we compared, but not in the other year.

- We clearly demonstrated the negative impacts of storage at temperatures that are either too warm (weight loss, softening, moldy calyx) or too cold (browning, pitting) on eggplants.

- Some varieties appeared to be more susceptible to chilling injury than others, while others were more susceptible to weight loss and softening when stored at warmer temperatures.

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Balancing Nutrients for Bell Pepper Vegetation & Fruiting

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In the Mid-Atlantic region, nutrient recommendations for bell peppers are shown below:

Peppers		Soil Phosphorus Level				Soil Potassium Level				
		Low	Med	High (Opt)	Very High	Low	Med	High (Opt)	Very High	
	N (lb/A)	P_2O_5 (lb/A)				K_2O (lb/A)				Nutrient Timing and Method
	100-180[1]	200	150	100	0[2]	200	150	100	0[2]	Total nutrient recommended
	50	200	150	100	0[2]	200	150	100	0[2]	Broadcast and disk-in or follow fertigation schedule
	50	0	0	0	0	0	0	0	0	Sidedress after first fruit set or follow fertigation schedule
	25-30	0	0	0	0	0	0	0	0	Sidedress later in season if needed or follow fertigation schedule

Apply 1 lb/A of boron (B) with broadcast fertilizer; see also Table B-7 in the Soil and Nutrient Management chapter. [1]If crop is mulched with plastic but not drip/trickle fertilized, broadcast 150 lb/A of N with P and K fertilizer. [2]In VA, crop replacement values of 50 lb/A of P_2O_5 and 50 lb/A of K_2O are recommended on soils testing Very High.

Fertigation Schedule Examples

This table provides examples of fertigation schedules based on two common scenarios – sandy coastal plain soils and heavier upland soils. Modify according to specific soil tests and base fertility.

Fertigation recommendations for 75 lb N and 125 lb K_2O[1,2] For soils with organic matter content less than 2% or coarse texture and low to medium or deficient K								
			Nitrogen			Potash		
Preplant (lb/A)[3]			**50**			**100**		
			N	**N**	**N**	**K_2O**	**K_2O**	**K_2O**
Stage and Description	Weeks	Days	lb/day	lb/week	lb/stage	lb/day	lb/week	lb/stage
1 Early vegetative	1-2	1-14	0.5	3.5	7	0.5	3.5	7
2 Late vegetative	3-4	15-28	0.7	4.9	9.8	0.7	4.9	9.8
3 Early Flowering	5-6	29-42	1.0	7	14	1	7	14
4 Fruit Development	7-8	43-56	1.5	10.5	21	1.5	10.5	21
5 Harvest Period[4]	9-14	56-98	1.8	12.6	75.6	1.8	12.6	75.6
Fertigation recommendations for 75 lb N and 75 lb K20[1,2] For soils with organic matter content greater than 2% or fine texture and high or optimum K								
			Nitrogen			Potash		
Preplant (lb/A)[3]			**50**			**50**		
			N	**N**	**N**	**K_2O**	**K_2O**	**K_2O**
Stage and Description	Weeks	Days	lb/day	lb/week	lb/stage	lb/day	lb/week	lb/stage
1 Early vegetative	1-2	1-14	0.25	1.75	3.5	0.25	1.75	3.5
2 Late vegetative	3-4	15-28	0.35	2.45	4.9	0.35	2.45	4.9
3 Early Flowering	5-6	29-42	0.5	3.5	7	0.5	3.5	7
4 Fruit Development	7-8	43-56	0.75	5.25	10.5	0.75	5.25	10.5
5 Harvest Period[4]	9-14	56-98	1.25	7.7	46.2	1.1	7.7	46.2

[1]Based on 7,260 linear bed ft/A (6 ft bed spacing). If beds have a different width, adjust fertilizer rates. Drive rows should not be used in acreage calculations (see the Fertigation section in the Irrigation Management chapter). [2]Base overall application rate on soil tests. [3]Applied under plastic mulch to effective bed area using modified broadcast method. [4]For extended harvest after 10 w continue fertigation at this rate.

Nutritional Disorders in Fruits

Blossom End Rot: This physiological disorder is caused by reduced Calcium (Ca) uptake and movement into fruit at low soil moisture. To control blossom end rot, maintain proper soil Ca, nutrient balance, and uniform, favorable soil moisture. This is especially important when cropping in raised beds for Phytophthora control, because soil in raised beds will dry more quickly than in flat bed culture.

Blossom end rot (BER) is a disorder where developing fruits do not have enough calcium for cell walls, cells do not form properly, and the fruit tissue at the blossom end collapses, turning dark in color. Calcium moves through cation exchange with water movement in the fruit, so the end of the fruit will be the last to accumulate calcium. Larger fruits and longer fruits are most susceptible. With fruits, the rapid cell division phase occurs early in the development of the fruit, the two weeks after pollination, and if calcium accumulation in the fruit is inadequate during this period, BER may occur. Over 90% of the calcium taken up by the fruit will occur by the time the fruit is the size of a nickel. While it may not be noticed until the fruit expands, the deficiency has already occurred and cells have already been negatively affected. We most commonly see signs of blossom end rot on fruits several weeks after the calcium deficiency has occurred.

The keys to controlling blossom end rot are making sure roots are actively growing and root systems are not compromised, soil pH is in the proper range, and irrigation is supplied in an even manner so that calcium uptake is not interrupted. Supplemental calcium fertilization will only marginally reduce blossom end rot if water is not managed properly.

Stip: In late summer and fall, pepper stip disorder can be a problem in bell peppers causing them to be unmarketable. It is particularly a problem on peppers taken to ripe stage such as red bells, but can also be an issue on green immature fruit. Pepper stip, also called color spotting or black spotting, is a physiological disorder of pepper fruit. It causes gray, brown, black, or green spots that are slightly sunken and are ¼ inch or smaller in diameter. Spots may be single or in groups and can resemble damage from stink bugs. Microscopic examination of affected areas shows dead collapsed cells with no evidence of cell puncture or insect damage. It is primarily a fall disorder and occurs most often when temperatures drop into the 40s and 30s. It can also occur after peppers are moved into cold storage. This is similar to what is seen with blossom end rot, only the affected areas are isolated and can occur throughout the fruit, not just on the ends.

The exact cause of stip is not known; however, it is thought to be a nutrient imbalance involving lower calcium (Ca) in fruit and high levels of nitrogen (N) and potassium (K). Research has shown that stip was most common in fields with low soil calcium or low pH and in fields with very high N and K fertilization. However, work in California showed that there was more stip in fields with higher lime additions.

Pepper varieties vary considerably in their susceptibility to stip. Research has shown that resistant cultivars consistently had lower N and K, and higher Ca concentrations than susceptible cultivars in leaf or fruit tissue samples.

In late summer and fall, there is reduced transpiration, and Ca movement in the fruit can be reduced. Excess N can cause rapid growth and extra foliage further limiting fruit transpiration and excess K can compete with Ca for plant uptake and cation exchange in the fruit.

Managing stip starts with using resistant varieties for fall production. Maintain high soil calcium levels and reduce nitrogen and potassium in fall production. Additional calcium through the drip system may help reduce stip. Foliar calcium applications have shown little or no effect on reducing stip.

Selection of Hot Pepper Varieties for a Diverse Value-Added Product Line

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In New England, the climate and growing season is conducive to many types of farming. The type of farming that a farm or a grower takes part in is determined by several factors. These factors include their location, their goals and their climate. Though New England, and the Northeast, are defined as similar geographically, New England is made up of varying terrains and climates that will impact what the goals of a grower are.

Kushi Farm and the North Hadley Chili Pepper Company, LLC, are both located in Hadley, MA in the Connecticut River Valley of Western Massachusetts. The agricultural land in the Pioneer Valley of Western Massachusetts is known as among the best agricultural soil in the world. Fertile soil, along with a temperate climate make the lands that surround the Connecticut River conducive to many different types of agriculture. One form of agriculture that has thrived in the Connecticut River Valley is vegetable farming.

In the Pioneer Valley, there is a high demand among consumers for local, fresh food and food products. This helps drive the demand for local agriculture along with value-added products derived from local agricultural produce. Value added products allow both growers and consumers to enjoy the benefits of produce season extension while also having a food product that can add flavor to many different food dishes that one may enjoy. Value added products can take the form of dry rubs, sauces, preserves, cold-stored produce, jams and jellies, among other products.

Both Kushi Farm and the North Hadley Chili Pepper Company strive to grow the best quality hot peppers for the consuming public. With an eye towards the value-added product line that defines the mission of the North Hadley Chili Pepper Company, Kushi Farm grows varieties of hot peppers that are popular in local cuisines. As a result, the peppers produced for the North Hadley Chili Pepper Company's Hot Pepper Jelly are hot peppers that are mainstream and known to most consumers – Jalapeno Peppers and Hot Red Cherry Peppers. These peppers rank in the middle of the Scoville Rating meter, which ranks the "hotness" of a pepper. Other hot peppers, such as Anaheim and Habanero peppers, are also grown to provide an ideal blend of hot peppers and flavors to the public.

Along with defining why and how you are growing certain varieties of hot peppers for your value-added product, following proper crop management best practices is the single most important factor in successfully growing and selecting hot peppers for your value-added product line.

Growing Peppers in New England

Growing hot peppers in New England's climate is straightforward and easy. Like many vegetable crops in the Northeast, hot peppers grow best when planted in the late spring and early summer. While different varieties of hot peppers can have different days to maturity, on average, hot peppers reach maturity in 75-80 days – roughly two and a half months.

Peppers can be started by the grower in greenhouses in the beginning of April, allowing for 6-8 weeks for the plants to reach proper height and maturity for transplanting. Growers can also arrange to have their transplants grown for them by another grower or by transplants from a farm/grower that sells ready to plant transplants.

Once hot peppers are ready for harvest, they can be picked continuously until either the harvest season is completed or to a time that the grower designates as their end of season time. Hot pepper plants typically provide high yields, with higher yields being obtained through proper cultivation best practices.

Selection of Varieties

At Kushi Farm, we grow several different types of hot peppers. Some varieties are strictly for the wholesale and retail markets that the farm sells through. Most varieties are active ingredients in our main value-added product line – developed through our complementary business, the North Hadley Chili Pepper Company, LLC. The two main peppers that are used for the North Hadley Chili Peppers Company's Hot Pepper Jelly are Jalapeno Peppers and Hot Red Cherry Peppers (aka Cherry Bombs). These peppers are grown by Kushi Farm as they represent a "milder" hot pepper. Jalapeno Peppers and Hot Red Cherry Peppers are in the lower to middle half of the Scoville Chart with a Scoville rating of roughly 2,500-8,000 Scoville units. When working with hot peppers, it is important to remember that the hotness that a pepper generates comes from the chemical Capsaicin, which the pepper produces and is held in the cell wall and ribs that hold the seeds.

(Scoville Chart: https://chettys.com/wp-content/uploads/2017/11/Scoville-Chart-1024x608.jpg)

Using two mid-range varieties of hot peppers allows us to produce a value-added product that can appeal to many different demographics. The use of these two peppers gives the North Hadley Chili Pepper Company's Hot Pepper Jelly enough heat to allow the consumer to enjoy a hot and spicy product while also keeping it mild enough so that it can be enjoyed as a complement with other foods. The goal of our Hot Pepper Jelly is to have a product that enhances the foods and dishes that it is used with. The same is true of other value-added products as well, such as Hot Pepper dry rubs.

Growing Conditions – Cultivating Peppers from Planting to Harvest

Cultivation Practices and Methods

Like many vegetable crops, hot peppers require the grower to follow proper cultivation best practices to successfully grow the crop and bring the pepper plants to maturity. Hot pepper plant yields will also be optimized with the adherence to proper crop management best practices.

At Kushi Farm, we have the pepper plants started in greenhouses in the beginning of April, allowing for 6-8 weeks of greenhouse maturation. At this stage, the pepper plants are ready to be transplanted into the fields. The plants are allowed to "harden off" in the natural weather elements for a week to prepare them for field planting. Hot pepper plants are then transplanted into the field, using a mechanical transplanter, in late May or early June.

To follow hot pepper crop management best practices, it is advised that growers keep the following tips in mind:

- Ensure that field has proper nutrient access and sufficient nutrient levels prior to planting
- Make sure that the plants have water access
- Keep the plants dry – do not allow standing water to pool in the field. Standing water can lead to disease and Phytophthora (Stem rot disease)
- Manage field and plants through cultivation and/or spraying to control weeds and disease
- Monitor plants constantly

Harvesting for Value-Added Product

Once hot peppers reach maturity, the grower can begin to harvest. For Kushi Farm, this is usually around mid-August. Jalapeno Peppers will be of nice size and may have a dark green color to them prior to turning red. Some peppers may show stretch marks, called corking. This means that the pepper is mature and ready to pick and will have a nice degree of hotness to it. Hot Cherry Peppers will be red and round and will snap off the stem with ease. Hot peppers can be used in a value-added product fresh or preserved through freezing until the time of use.

Final Analysis

The keys to success in selecting and growing hot peppers for a value-added product line is understanding your land and what it can do for your crop, your reasons for growing the crop and following proper crop management best practices.

Growing Honeyberries in Northern New England

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Wayside Farm is a small family farm begun in 1982 in the small rural town of North Sandwich in central New Hampshire. Started initially as a part-time farm to grow vegetables for sale locally, we have evolved into growing seasonal annual and perennial flowering plants for area gardeners. We produce the plants we sell in 13,000 square feet of heated greenhouse space and on several acres of land.

In 2012 we started a plan to grow edible fruit crops that would be less labor intensive and not require annual plantings. Our concept was to plant and harvest small fruits as a strictly wholesale crop, with only a very minor portion to be sold fresh directly to customers at our farm. We also intended on marketing the same plants to our existing gardening customers to help build interest. In 2013 we planted 500 highbush blueberries, a thousand feet of raspberries, and a 4000-plant tower-type hydroponic strawberry structure. After the winter's research, we purchased 500 honeyberry (Loniceras caerulea) plants to fill out our concept. We registered our new subsidiary business name GREAT NORTHERN BERRIES to focus our initiative on selling wholesale fruit produce and fruit plants for sale. To date, we have trialed 28 varieties of honeyberry plants.

Honeyberry basics:

- 'Honeyberry' is a common term for the shrub Lonicera caerulea and used often interchangeably with the name 'haskap', and also known by the common names of 'edible blue honeysuckles', 'sweet berried honeysuckle' and 'blue honeysuckle'.
- Native to circumpolar areas of the world; various species are found in Siberia, Northern Japan, Canada and Finland.
- Found wild in northern riverine areas in often mildly alkaline gravelly soil, but also in wet acidic peat areas.
- Seem to thrive in a PH anywhere between 5.5 and 7.5, but more research is needed.
- Some sub-species of native plants may mature at 18", while others probably grow to 8 feet or more.
- Being native to areas so far north, they begin to flower very early (approximately April 26 in central New Hampshire), fruiting from mid-June to early-July here, and start to go dormant by mid-August.
- Honeyberries are rated to at least zone 2, and the early flowers seem frost-hardy to 22 degrees. No winter hardiness issues observed.
- Differing varieties not too closely related, but with similar timing, need to be planted to cross-pollinate.
- Bob Bors at the University of Saskatchewan has developed, refined, cross-bred and trialed varieties and Maxine Thomson at the University of Oregon has had an ongoing research program and released numerous varieties to the industry as well. There are other research and development programs elsewhere as well.

Planting, Growing, and Other Considerations:

- Our initial 2013 plantings have rows 10' apart with plantings 4' on center and with ½ gallon per hour button trickle irrigation at each plant. 2 gallons water applied per week from late May – early August; and 4" aged sawdust mulch down the row. PH is targeted in the 6-7 range, and grass is mowed between rows.
- A subsequent leased 3 acre off-site orchard of 3000 plants (including 100 aronia) was begun in 2016 on raised beds with a permanent woven mesh (groundcover) mulch and trickle tubing. Spacing here is also 4 ft. within the row and 10 ft. between rows. Irrigation water is provided from river water with gasoline pump when needed 2 times a week at 1.5 gallons/ ft. Orchard grass is mowed between rows.
- Honeyberries are a vigorous crop, producing a small amount of fruit in the second year and fresh shoots up to 2 ft, and up to 4 ft on mature plants.
- Plants seem to need a fair amount of nitrogen: currently we're feeding ½ pound 10-20-10 per plant in early May, broadcast across the rows and aisles. This may not be enough.
- Pruning and thinning even 3 year plants can improve yields, size and quality of fruit. On 5 year plants I take out as much as a third of the plant every other year, removing some center growth, the oldest branches and managing the shape and plant width.
- For pollination, we rely on native bumblebees, which are cold-hardy bees and have always been common at our farm. Pollination generally takes place between about April 28 and May 16, depending on varieties. Class B bumble bee hives may be needed.

Harvests and Marketing Considerations:

- Yields on our mature (5 year old) plants average about 4 pounds, with some varieties yielding only a pound, while others as much as our plant record of 17 pounds.
- Berries have a tender skin that melts in your mouth and seeds are un-noticeable.
- Taste between varieties and between years can vary greatly with sweetness increasing until berry-drop. The flavor is generally somewhere in the blueberry/raspberry range, some with strong plum or cherry flavors. Berry size may be increased with irrigation.
- We chose not to entertain pick-your-own honeyberries for several reasons: Food Safety considerations, berries are tender when ripe and easily damaged, most varieties mature fairly uniformly and need to be harvested when ripe, remaining berries still need to be harvested after PYO.
- We chose not to emphasize fresh sales due to: our low area population; many varieties are easily bruised or wounded during harvest; very short shelf life. Subsequently, we have determined that a few varieties may be suitable for our fresh market sales.
- We harvest in bulk using a manual pneumatic olive shaker made by Campagnola with a gasoline powered compressor; collecting the berries onto nets and into fruit lugs. We winnow with a small battery powered leaf blower and quick-freeze overnight. Frozen berries are then cleaned, sorted and the still frozen berries are bulk packaged into 25 pound boxes.

Challenges:

- Weeds are competition to new plantings, especially annual weeds when planting 2 ¼" young plants in spring. Our best and most efficient plantings have been using 4" or larger potted plants, set in October and early November.
- Insects have not been a serious problem in our area to date. Berries seem to be harvested before SWD or Japanese beetles are a problem, and other minor pests do not bring us to the threshold of needing to spray our crops.
- Predators to consider include bear, deer and fox. We use electric fence netting (sheep-type) to keep out bear and fox at the Farm, and a 3-D type stranded electric fence at the river orchard to deter deer.
- And then there are the birds….
  We found out very quickly that cedar waxwings, a Federally protected species, present a major problem. Our perspective is that netting is mandatory. Turkeys can also be a problem.
- Plant diseases have not been an issue here. Some plants may be prone to mildew on both leaves and fruits, but if the canopy is not too thick and is kept off the ground, fruits are not affected. Late mildew and sunscald on the foliage does not bother the plant, since it is done growing by then and is beginning to hibernate.
- Marketing plans are important to develop early on for this little known fruit, since that will lead into differing planting, harvesting, storage and sales systems.

HONEYBERRY VARIETIES WE HAVE TRIALED

Best fresh quality	Mechanical harvesting	Unproven	Discontinued varieties
Aurora (M)	Berry Blue (E)	Keiko (L)	Blue Forest (M)
Blue Moon (L)	Blue Bird (E)	Rebecca (L)	Blue Fortune (L)
Blue Pacific (L)	Blue Hokkaido (L)	Taka (L)	Blue Mist (L
Blue Sea (L)	Blue Nova (E)	Tana (L)	Blue Pagoda (L)
Blue Sky (E)	Honey Bee (E)		Blue Velvet (L)
Borealis (E)	Larissa (M)		Erin (L)
Cinderella (E)	Polar Jewel (E)		Evie (M)
Indigo Treat (E)	Tundra (M)		Indigo Gem (E)

Plant sources we've used:

- Adamson's Heritage, Langley, British Columbia
- Agri-Forest Bio-tech, Kelona, BC
- Honeyberry USA, Bagley, MN
- LeHave Natural Farms, Nova Scotia
- Northwoods Nursery, Molalla, OR
- Prairie Tech, Alberta Ca
- Sidhu Nursery, BC

Kiwiberry Production in New England

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Flavorful and nutrient-dense, the snackable kiwiberry (*Actinidia arguta*) has an extensive 140-year history of cultivation in New England, first as an ornamental landscape vine and subsequently as a novel fruit crop on private estates and in backyard gardens. In more recent decades, a handful of producers have experimented with field-scale kiwiberry production; and such pioneering work has not only demonstrated the commercial viability of the crop in our region but also helped catalyze interest among consumers and researchers. To support the development of kiwiberry as a new, high-value fruit crop for the northeast, the New Hampshire Agricultural Experiment Station (NHAES) launched a long-term kiwiberry research and breeding program in 2013.

There is great potential for establishment and growth of a kiwiberry sector in the northeast due to the combination of consumer interest, an established valuation of local produce, our unique culture of direct-market horticultural crops, and the low level of regional production to date. Before investing the time and resources required for a successful kiwiberry operation, however, prospective producers should be aware of the details of such an enterprise, whether as a standalone system or as an added component to an already diversified farm. Vines of currently available varieties may take up to seven years to reach full production, and growers should not consider kiwiberry production anything other than a long-term, intensively managed investment. To meet growing demand for information on best production practices the research program has developed a step-by-step production guide which is coupled with the best available regional enterprise data, intending to provide interested growers the necessary information to decide if, how, and at what scale they should embark upon such an enterprise.

The production guide and enterprise analysis are presented digitally to allow for ease of circulating the latest program updates, and may be found at:

www.noreastkiwiberries.com

Hops Production in New England

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Hops were a major crop in the Northeast in the early 1800s, before disease pressure and the appeal of the Pacific Northwestern climate drew the hops industry to the other side of the county. Currently, New England is home to over 175 high quality microbreweries. Public interest in sourcing local foods is also extending into beverages, and the current demand for local and organic brewing ingredients is quickly increasing. The breweries in New England want locally grown hops to create niche brews for local markets. This demand has created a niche market potential for many farmers. However, there is very little information on how to grow hops in our region. Hops are primarily grown in the Pacific Northwest a climate that is far different than ours. Since 2009, UVM Extension has been working to develop regionally relevant production and processing information on hops.

Construction of a Hopyard

Hops are grown on vertical trellis systems that are built to heights of 22 feet. A complete list of materials and videos on the construction of the UVM Extension hop yard can be found at www.uvm.edu/extension/cropsoil/hops. Low trellis systems are possible but require specific varieties that produce cones at lower growing heights. Hops require substantial quantities of water throughout the growing season and irrigation is a necessity to produce high yields. Drip irrigation is the most common system implemented in hopyards in the Northeast. Costs for implementing an irrigation system and a YouTube video on how to set up irrigation in your hopyard can be found at http://bit.ly/poHHoy.

Selecting Hop Varieties

Proper variety selection is essential to producing high yielding hops in the region. Publicly available varieties can be secured from a number sources located throughout the U.S. Hops can be purchased as rhizomes, rooted cuttings, or plants. Rhizomes are the cheapest source of hop material but may also be laden with diseases including downy mildew and various viruses and viroids. Purchasing plants or rooted cuttings that have been confirmed to be "disease-free" will get your hop operation off to a good start! Selecting varieties that have some disease and insect tolerance will also be important as pests can reduce hop yields significantly. Lastly understanding what types of hops brewers are interested in purchasing can further guide the varieties that you might select for production. UVM has conducted research to identify varieties that perform well in our region. After four years of research, the most successful varieties were clear. Several varieties did not survive pest pressure or lacked winter hardiness. Table 4 indicates varieties that performed well and those that did not.

Table 4. *High and low performing hop varieties after four years of evaluation.*

High Performance Cultivars	Low Performance Cultivars
Centennial	Liberty
Chinook	Crystal
Newport	Saaz
Cascade	Sterling
Nugget	Cluster

Fertility Management

Hop plants prefer to grow in a soil with a pH ranging from 6.0 to 6.5. For the lime to react quickly, it is best to mix it in with the soil. In some cases, the pH maybe too high. A pH over 7.5 should be lowered, as certain nutrients are less available to plants above that range. Soil amendments such as sulfur fertilizers, pine needles and peat moss will lower the pH. Since it takes time for the soil pH to change, it is best to correct soil pH prior to establishment.

Nitrogen - A hop crop will require a substantial amount of nitrogen (N) to meet growth requirements. A high yielding hopyard can remove between 100 to 150 lbs of N per acre from the soil. Nitrogen application rates are often based on knowing your whole plant biomass yield. Higher yielding plants will obviously require more N per acre to promote plant growth and development. A whole plant biomass yield of 1000 lbs/acre will remove 80 to 90 lbs of N per acre from the soil. As the cone yield increases to 2000 lbs/acre the hop plant can remove 150 to 170 lbs/acre of N from the soil. Nitrogen rates should be based on yield but also soil organic matter level and/or soil type. Nitrogen should be applied about 30 to 45 day after emergence or mid-May to mid-June. The primary N uptake period for hops occurs during the vegetative stage (May through early to mid-July). It is important to not apply N after flowering as this can lead to unwanted vegetative growth. Split applications of N are recommended on lighter textured (i.e. sandy) soils where leaching is an issue.

Phosphorus - Hops do not require high levels of phosphorus for acceptable yields. It has been shown that a 2000 lb/acre crop of whole plant biomass removes an average of 30 lb/acre of P from the soil. Most of the P in hops is found in the cones and the rest in the remaining plant parts. If leaves and vines are returned to the soil, there is actually very little P exportation from the soil. If soils have optimum levels of P, approximately 20 lb/acre of P should be applied to the soil. Low levels of soil P would warrant an application rate of between 60 and 100 lbs of P per acre. Soil test P levels in the Medium range would require 40 to 60 lbs of P per acre.

Potassium - Hops will remove 80 to 150 lbs of K per acre. Interestingly, most of the K taken up by the hop plant is retained in the leaves and stems with very little in the cone. Returning hop leaves and stems to the yard would be a means to replenish soil K levels. If your soil test K falls in the high range, K does not need to be added to the soil. A medium soil test K result might require the application of 80 to 100 lbs of K per acre. However, if soil test K levels are in the low range, 150 to 100 lbs/acre of K fertilizer should be amended to the soil.

Micronutrients – Boron deficiency has historically been a problem in the Northeast, especially in crops such as alfalfa and clover. Boron deficiency in hops has been reported in the Pacific Northwest. As a basic guideline, 1 to 2 lb/acre of B should be added annually to the hopyard. Zinc deficiency can also be an issue in hop production. Similarly, Zn deficient corn has been observed in the Northeast. Soils that have an especially high pH, low organic matter, and a light texture can be prone to low zinc levels. Based on PNW information, an application of 2-4 lbs/acre of Zn should be amended if soil test levels are lower than 1 ppm.

Pests and Management

Seven hop yards in Vermont were scouted for arthropod pests and natural enemies every other week June-August for three years (2012-2014). The goal was to identify the major arthropod

pests. The major arthropod pests in NE hop yards were two-spotted spider mite, hop aphid, and potato leafhopper. Higher populations of hop aphid were observed in cooler, moister seasons while higher numbers of two-spotted spider mite were observed in seasons of dry heat. Secondary outbreaks of spider mite were observed following broad-spectrum pesticide sprays targeted at potato leafhopper. Proper identification and scouting (pests and beneficials) is important especially before insecticides are to be applied. More information on hop arthropod pests and management can be found at www.uvm.edu/extension/cropsoil/hops.

Downy mildew (Pseudoperonospora humuli, Miyabe and Takah,Wilson) is the primary disease issue of hops in the Northeast. Downy mildew can cause the complete loss of marketable hop yield, and even hill death in sensitive varieties. It is a very serious hindrance to successful hops production, but diligent integrated pest management (IPM) can help reduce disease infection, and/or help control downy mildew once the disease has reached your hopyard. A combination of scouting, mechanical control of early season disease combined with appropriate fungicide applications has been successful in controlling this disease in our region. Identification and control options can be found at http://www.uvm.edu/extension/cropsoil/wp-content/uploads/DownyMildew.pdf.

Harvesting and Processing Hops

The reintroduction of hops through-out the US requires scale-appropriate harvest and processing equipment. In 2011, there were no feasible mechanized harvest options for a 1-2 acre hop producer. Handpicking was the most wide-spread practice which is labor intense and time consuming leading to expense and quality impact due to delayed harvest. Mechanized harvesting can increase harvest rate by a factor of 100. Mechanized harvesters were available but were capitally-intense and required import and modification for use in our country. Early re-adopters of hops in the northeast are eager to have an option for mechanical harvesting of the crop to reduce production costs and improve overall quality. The presentation will summarize advancements in mechanized harvest options. A mobile, trailer-based mechanized hop-harvester was developed and documented as an open-source design for others to replicate at UVM. The design was the result of a collaborative design effort involving growers, brewers, agronomists, fabricators and engineers. Additionally, several hundred people have downloaded the plans for the machine and there have been 8 replicates partially informed by this work. Commercially produced, scale-appropriate harvesters are now available for the smaller scale producer. Some have been based on the open-source design work. Designs and videos of the UVM Harvester can be found at http://www.uvm.edu/extension/cropsoil/hops. In addition, there are now local companies that manufacture and sell harvesters for small scale growers.

In addition to harvesting improvement, growers require systems for post-harvest management of the crop including drying, baling, pelletizing and storing. Small scale models of balers and driers have been designed through UVM as well as many farmers in the region. We will cover current best practices in this area as well.

New England Cider Apple Project

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In a recent survey of apple growers, one prominent Vermont apple grower stated, "*The cider apple market represents the first real increase in demand for New England Apples in a generation. While sales of our dessert fruit have been flat or declining, we see this market as essential to maintaining the competitiveness of our industry*."

Fermented cider production in New England experienced over 50% annual growth from 2009 to 2014 and sales of regional craft ciders made from specialty cider apples increased over 40% in 2017. That last figure is especially important, because cideries use two sources of apples for making their products: culled fruit of traditional dessert apple varieties (e.g. 'McIntosh', 'Empire', etc.); and specialty varieties grown specifically for their unique flavor and aroma contributions to the finished cider. The former of these apples make up the lion's share of fruit used for making cider in the U.S., and their production requires a wholesale dessert variety market that provides sufficient revenue so that growers can afford to sell culls at substantially lower prices. At regional educational meetings in 2014-2017, and in national surveys since 2014, apple growers stated that biennial bearing, variety adaptability, appropriate orchard training systems, and increased susceptibility to specific diseases, particularly fire blight, present significant limitations to increased expansion of cider apple production.

Specialty cider apple varieties, however, present greater value as cider apples than dessert varieties that are downgraded for cider use. Thus, cider varieties do indeed present opportunity for diversification of New England orchards without substantially changing production systems. Currently, the demand for cider apples exceeds supply, and apple varieties specifically selected for cider (e.g. 'Dabinett', 'Ashmead's Kernel', 'Franklin Cider Apple') offer high returns for growers. Cider apples also have lower infrastructure and management needs because lack of demand for blemish-free fruit creates an opportunity to grow them with fewer chemical inputs. In addition, postharvest cold storage, sorting, and packing are greatly reduced compared to dessert apples. However, production of cider apples is limited by unknown performance metrics for specialty cider apple varieties when grown in New England, unique pest management considerations including greater susceptibility to fire blight, and alternate bearing cycles that reduce yield. There is a dearth of objective, research-based information on cider variety

performance across New England orchards. However, there are many growers whose expertise growing these fruit can be collected through citizen science to develop regional recommendations for cider apple production. In addition, new methods for managing crop load through use of plant growth regulators and/or canopy hedging could address biennial bearing issues that reduce cider variety productivity.

New England Cider Apple Project

In fall 2019, specialists from the Universities of Maine, Massachusetts, and Vermont initiated the New England Cider Apple Project (NECAP) with funding from the Northeast SARE Research and Education Program. This project includes four research components that will yield valuable information for New England fruit growers":

1. *Cider variety observations*.
In 2019, NECAP staff began collecting field observations of cider varieties in several orchard in Vermont and Massachusetts. Data is being collected on tree growth (vigor, habit); biennial bearing tendency, crop yield; juice quality; and incidence of disease and pest damage. Beginning in 2020, we will solicit growers for your observations and data, if available, to build out profiles of popularly-grown cider apple varieties in the region.

2. *Mechanical thinning research*.
Traditional European cider varieties do not respond as well to chemical thinners as most dessert varieties. In Maine, we will evaluate the effectiveness of a mechanical string thinner for effectiveness in early flower thinning, yield, and biennial bearing.

3, 4. *Return bloom: Plant growth regulators and canopy hedging.*
The success of the highly biennial dessert variety 'Honeycrisp' has led to research on and recommendation for treatments to improve annual bearing tendency. The use of post-thinning plant growth regulators and trimming vegetative shoots through hedging cam improve return bloom the following year independent of crop thinning. These treatments will be tested on commercially-important cider varieties to assess their effects on crop yield, return bloom, and fruit quality.

Work completed to-date is preliminary, and thus we are not ready to make recommendations based on it. The intent of this session is to introduce the project to cider apple growers from across the region to invite participation in project activities, including collection of observations from your orchards. As this project unfolds, we will publish results on the NECAP website at http://go.uvm.edu/necider.

Funding for this project is provided by NESARE Grant LNE19-373.

Growing Apples for Hard Cider Making

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Since 2005 my wife and I have owned and operated Butternut Farm, which is a 25 acre pick your own fruit farm located in Farmington NH. Following the difficult growing seasons of 2014, 2015, and 2016 we decided to further diversify our fruit business into hard cider production. Since then our sales have been primarily directed to the end consumer through our already established retail farm outlet.

My experience with making hard cider began in December of 2016 when I purchased a couple of glass carboys and a home hard cider making kit. Since then the farm has constructed a farm cidery, planted various bitter sweet, bitter sharp, and heirloom varieties for the sole purpose of making into hard cider, gotten state and federal licensing in order and completed two commercial seasons of hard cider production and sales. This coming winter we plan to ferment about 3000 gallons of cider.

In this presentation I will discuss which varieties of "dessert" apples we like to use and why! In particular how they impact the pH and sugar content of the pre ferment juice. Storage characteristics and juice yield are also important factors to consider in apple selection.

I will also reflect a bit on our first crop harvested in 2019 from three of our hard cider varieties. The 3rd leaf Franklin, Porters Perfection, and Rhode Island Greening gave us about three bushels all combined. The Hereford Red Streak, Ashmead's Kernal, and Ellis Bitter have yet to bear a crop. We have planted about 80 trees on 10*18' spacing on semi dwarf roots like: M26, G202, and G30. So far they behave a lot like the rest of our trees. Vigor does not seem to be a problem and they have been getting sprayed, fertilized and cared for just like any dessert variety would at our farm. Bi-annual bearing is a major concern looking forward. Crops will be thinned, Orchard fertility will be monitored closely, and multiple summer/fall re-bloom sprays of NAA, ethrol, and vitazyme will be used to hopefully mitigate the extreme bi-annual tendency I have heard many of these varieties have.

25 Years of Tunnels: Through the Looking Glass or Down the Rabbit Hole?

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Something happens over time and occasionally it's a good idea to stop, take a breather and look back to see what exactly it was. What originally started with a 7' by 9' glass greenhouse from Agway has evolved into 25 structures from 6 different companies. Eight greenhouses have top vents, two are moveable, two are gutter connected models, twenty have heaters, sixteen are certified organic, nine are for flowers, all have wireless monitors, twenty have hard-wired monitors, 5 are computer controlled and they all require planning and constant maintenance. Each structure is unique and there is a learning process to understand how their environment and placement will yield the best results for the crops grown within. Here's a few things we've learned that might save you some time to get those quality crops grown and harvested.

Structures: We have structures that run north-south and others that run east-west. There doesn't seem to be much difference in the direction chosen if they're built in a location that receives full sun. That's not sun for 5 or 6 hours per day. Full sun is 8 to 10 hours per day in the summer. You should face them away from prevailing winds if the top vent is only on one side.

Another important concern is drainage. The weather extremes are producing more intense and severe rains and all that water that comes pouring from your structure needs a place to go. Some of our structures have gutters which funnel water to 8" underground drainage pipes that empty into grassy fields. Others have swales that channel runoff away from baseboards and the inside growing area. Climate change is the main reason we have continued to build inside growing areas that can be protected from the roller-coaster high and low temps and extended wet or dry spells.

Insulating baseboards with 1" or 2" blue board or similar material have increased our winter growing space by one foot on each side inside the structure. That's close to $1/10^{th}$ the square footage of a 21' wide tunnel. Multiply that growing space over 10 years and it's equal to another similar structure.

One winter note – Although snows in our area are nowhere what they used to be, we can still get accumulations of ice and smaller snows that threaten the structures integrity. Two layers of inflated plastic help snows slide off more easily. If you do have to shovel or plow, remember to start in the middle of the greenhouse, remove about $1/3^{rd}$ and then do the middle of the other side to eliminate the snow build-up weight from pushing the greenhouse and bending the bows. If an extreme storm is expected, we usually start pre-heating the structure when possible to 75-80 degrees about an hour before the first flake and for the duration of the storm to have a warm covering that can melt much of the snowfall.

Amendments: Once the site is chosen, a soil test, more specifically a long-term high-tunnel soil test from the University of Maine is essential for proper crop growth. We use fairly heavy

amounts of composted cow manure to help with fertility and organic matter. Depending upon the soil test results we'll also apply organic granulated fertilizers, sulfate of potash, gypsum, Azomite, Black Earth humates and Nature's Source 3-1-1, all OMRI certified products.

Tools: Some of our tunnels will allow us to use a low-profile tractor that can apply compost, do subsoiling and rototilling inside the structures. We have a tractor wide door on a gutter-connect and removeable end walls on a number of other tunnels. On the smaller structures we manage the crops with BCS rototillers and an assortment of small tools such as these:

Pyroweeder from Farmer's Friend: https://farmersfriendllc.com/products/weed-management/pyroweeder-flame-weeder

Dibbler and Tine Weeder from Two Bad Cats: https://www.twobadcatsllc.com/index_files/fproducts.htm

Farmer's Broadfork from Meadow Creatures: https://meadowcreature.com/broadforks?gclid=Cj0KCQjw3JXtBRC8ARIsAEBHg4mGYfdRvrRiZZWK54uxxmZdCP_fiEAAlcHW-HNa44eDqZ6Z4CVkI5kaApftEALw_wcB

Terrateck Double Wheel Hoe with finger weeders: https://www.johnnyseeds.com/tools-supplies/long-handled-tools/wheel-hoes/terrateck-double-wheel-hoe-7620.html

Of course the most essential tool, one you should get before you start construction, is a greenhouse monitoring system. We use a wireless system that has options for humidity as well as temperature and a wired system that uses daisy-chained thermostat wire to a control box in our home. You can find samples of those here:

Monnit Systems: https://www.monnit.com/Product/MNS-9-W1-HU-RH/ (requires gateway & software)

Thermalarm: https://www.farmerboyag.com/Thermalarm-III-NO-Lever-Set (hook up to alarm or electric doorbell) or if you're really lucky you might find one of these by the Thermalarm company. Call them to get a source): Protect-it: https://www.thermalarm.com/Products/protectit.html

Rodent control: Best rat, vole and mouse traps we've found: https://gemplers.com/collections/all/products/kness-snap-e-rat-trap

Crops: Most of our tunnels grow three crop cycles, some only two but the more you can turn them over the better. I guess hemp has replaced tomatoes as the most valuable inside crop but aside from the regular high-tunnel crops we have had good response from our customers growing these:

Ginger and Turmeric – planted every foot can give nice dollar yields. Vacuum freeze any extra for winter CSAs.

Organic bedding plants – A 14’ by 96’ greenhouse can hold 750 10” X 20” flats. Eight six-packs per flat at $4 each = $32 X 750 = $24,000. A 15 tray of 4.5” herb pots at $4.50 per pot = $67.50 X 750 = $50,625. That’s a lot of spinach. Do you have folks coming to your spring CSA or farmer’s market? Maybe specialize in hot peppers or heirloom tomatoes.

Potatoes – We plant cut seed potatoes in 4” pots in early April then plant when shrub-like into a high-tunnel for 4th of July harvest of red, white and blue. (and gold!)

Onions – We’ve had better luck seeding various onions for tunnels in mid-January for June harvest. Others like to overwinter but we seem to have less die-back and better weed management with our method.

Celery – Thank you to the author of the celery cleanse diet. Celery prices skyrocketed last spring from $35 per case to $120. We like it as a winter crop as well as a spring crop and although the bunches tend to be smaller, they’re much sweeter in cold weather.

Carrots- Planting carrots outside for eventual cover by our moveable tunnel in early August allows us to have really sweet roots with green tops in December to supplement our Bolero storage crop.

Cut flowers: Especially lisianthus. Flowers grow much cleaner and with taller stems when protected. We’re still picking lisianthus bouquets well into October.

Summary: One thing I’ve learned over the years is that the more I know, the more I realize there is to learn. Thanks to early partnerships with high-tunnel guru Otho Wells and greenhouse supplier Ed Persons, I was fortunate to shorten the learning curve considerably. Also, partnering with UVM extension’s Vern Grubinger (who happens to live in the same town) and the Tri-State IPM program, we solved a lot of mysteries and prevented many an infestation. Vegetable growing is all about networking and we’re fortunate to live in an area that believes in sharing knowledge. Good luck with your tunnels and if you think what you have is your last one – think again!

High Tunnel Research Update

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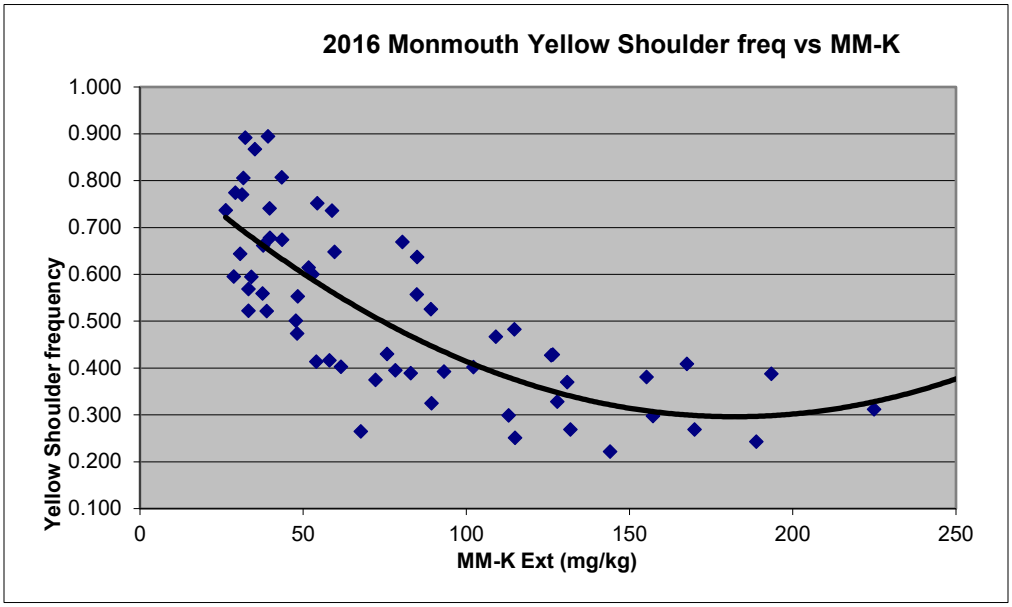
For nearly 10 years, University Research and Extension staff have been working to update fertility recommendations for high tunnel production. Very high yields and extended/multiple cropping cycles put a very high demand on high tunnel soils. The Northeast High Tunnel Research Group (Extension faculty and staff from ME, NH, and VT) completed a 3-year SARE-funded research project on Organic High Tunnel Tomato Production. This project included an IPM component, documenting the success of various habitat plants in attracting natural predators.

The fertility component concentrated on marketable yield response to potassium, which is chronically deficient in many tomato house soil tests. Potassium (K) was applied as OMRI sulfate of potash (0-0-50) at 0, 150, and 300 lb K_2O/acre in 2016 at two locations in NH and one location in ME. Nitrogen was held constant at 300 lb/A as NatureSafe (13-0-0): ½ at planting and ½ at first fruit set. Soil samples were taken at planting time and at end of season and analyzed by both the modified Morgan (MM) and saturated media (SME) test methods. Foliar samples were also taken at first fruit set and end of season. Total yield, culls, marketable yield, and yellow shoulder frequency were measured cumulatively for the season. Significant responses in marketable yield per plant and in yellow shoulder frequency were seen at some but not all locations. It was discovered that some of the coarse granular potassium sulfate had not dissolved and released in dry zones between drip lines, resulting in skewed soil test results in some cases. This greatly complicated yield and quality response statistics.

Figure 1.



Potassium application was repeated in 2018 in the same houses at 0, 300, 600, 900 lb/A K_2O application rates, using a fine granulation of 0-0-50. Some potassium sulfate treatments were dissolved in hot water before application to some plots, prior to mixing, to ensure complete release. Nitrogen application was split, as in 2016. Application rates for K were greatly increased over 2016 after noting substantial depletion of soil K at lower 2016 application rates. Significant responses in marketable yield and yellow shoulder frequency were again seen at some, but not all locations. Since the same plots were used for 2018 and 2016, coarse granules from 2016 were still present and again complicated responses.

Similar significant statistical relationships between marketable yield and MM- K were seen between the two application years on some sites, with maximum marketable yield occurring between 450 – 500 mg/kg (900 – 1000 lb/A) available K in pre-plant or early season MM soil tests. Yellow shoulder frequency was minimized at MM-K levels lower than those for maximum marketable yield (figure 1). Foliar K levels were also significantly correlated to soil test K. However, in all years maximum foliar K levels for all treatments were much lower than established guidelines for field-grown tomatoes, indicating a need to revise optimum foliar K levels in high tunnel grown tomatoes.

In 2018, the Research Group was expanded to include additional Extension staff from VT, MA, NH, and RI. A New England Regional High Tunnel Survey was undertaken, sponsored by the New England Vegetable & Berry Growers Association. Commercial growers in 4 New England states were chosen, for a total of 20 tomato houses. There was no alteration to their normal production practices. Growers and Extension staff documented choice of varieties, fertility practices, pest frequency and control practices, grafting and pruning methods, irrigation practices, and their effect on total yields. Each house was soil sampled at planting time and soil and foliar sampled once each month for the entire growing season. The concept of the Survey was to document any common practices between successful long-term growers and their effects on yield and quality.

As might be expected, cultural and fertility practices covered a large range: 13 of 20 farms planted Geronimo, 12 of 20 farms grafted their plants, 11 of 20 fertigated, 9 of 20 pruned to more than 1 leader, only 3 of 20 did not use some type of mulch. Transplant dates ranged from the end of March to mid-May, with spacing ranging from 3 - 7 sq ft per leader. Total yields ranged from 1.5 – 5 pounds per sq ft. Higher yields generally occurred at tighter spacings.

Soil pH's were generally in the optimum range of 6 – 7. Organic matter ranged from 3 – 12 %. Soil nitrate levels covered a huge range. Several houses were consistently below the 100 ppm optimum soil water (SME test) range for nitrate throughout the season. However this was not reflected in foliar N levels, which mostly fell in the optimum 3.5 – 5.0 % range. Apparently plant demand and uptake closely matched mineralization rates in the soil, keeping soil test levels low. Both soil reserves (MM) and foliar levels of phosphorus (P) were in the acceptable ranges, though some soil water levels were below optimum. One standout result was a consistently low soil water K level in the SME soil test for many of the houses, which was often reflected in full season available K in the MM test. This correlated with a consistently low foliar K levels for most houses, often well below the 2.5 % lower limit of sufficiency in greenhouse tomato foliage. This was not surprising, considering the very high K demand of tomatoes and consistently low

soil test K levels seen in many tomato houses year after year in routine testing. It also pointed out the need to recommend and apply more K for high tunnel tomato production.

A large amount of response data and information on good cultural practices accumulated from both the High Tunnel Work Group research and through the Regional High Tunnel Survey over the past several years. There are also several good references on N-P-K crop removal by both field grown and high tunnel tomato production: New England Vegetable Management Guide (field grown), the Haifa Group (tunnels), Minnesota High Tunnel Production Manual, and Ag Canada research from 1964 by Ward (tunnels). Most of these references were in general agreement as to pounds per ton of fruit crop removal for N (4.5 – 6.0 lb/T), K_2O (10 – 11.3 lb/T), and P_2O_5 (1.8 – 2.7 lb/T). Vern Grubinger and Katie Campbell-Nelson took the lead on creating a fact sheet, summarizing BMP's from the Regional Survey and listing revised optimum foliar and soil test nutrient levels for high tunnel grown tomatoes.

The fact sheet also includes yield-dependent N- P_2O_5- K_2O recommendations for Low-Medium-Optimum-Above Optimum MM soil test levels. These are based on the published references listed above and the K response work from the Northeast High Tunnel Research Group. Fruit yield goals (figure 2) are labeled as **Low** (20 T/A or 1 lb/sq ft), **Medium** (40 T/A or 2 lb/sq ft), **Good** (60 T/A or 3 lb/sq ft), and **High** (80 T/A or 4 lb/sq ft). The recommendation guide is based primarily on full-season P & K availability from the modified Morgan field soil test, but also incorporates short-term availability of N, P, and K from the soil water SME test.

Figure 2.

N application rate based on 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
Tunnel low yield	40,000	1	4	8'	100	2.3
Tunnel medium yield	80,000	2	8	12'	200	4.6
Tunnel good yield	120,000	3	12	16'	300	6.9
Tunnel high yield	160,000	4	16	20'	400	9.2

Reduce target N application by 10 lb/acre or .23 lb per 1,000 ft^2 for each 1% organic matter, up to 4%.

An optimum test level for P or K in the MM soil test may not be reflected in the soil water (SME) test. This indicates good full-season availability, but less than ideal short-term availability. This can be a problem, especially for critical early-season uptake and growth from cooler soils prior to fruiting. Additional water-soluble sources of P and/or K are recommended in these cases. Providing sufficient nitrogen for the entire season can be a problem in sandy soils or for higher yield houses. We have found in our research houses that splitting the nitrogen application and applying about ½ of the recommended N when fruiting begins will ensure an ample supply through the end of the season. It is also a good practice to split the potassium

fertilizer application, especially on sandy soils which tend to deplete K more rapidly. Applying ½ the recommended K when fruiting begins will extend availability and uptake through the end of the season.

The Northeast High Tunnel Research group will continue refining fertility, management, and cultural practices in high tunnel production of several other crops grown in high tunnel production systems. Plans are currently underway to work on winter greens production. It is also our intention to continue organizing high tunnel conferences and workshops.

If you have questions on management problems or have suggestions for research objectives, please contact one of our members listed on the regional fact sheet, which can be accessed online:

(http://www.uvm.edu/vtvegandberry/Pubs/TomatoHighTunnelStudy2018.pdf)

Heating the Soil for High Tunnel Production: Pros, Cons, and Numbers

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Overview: In early 2018 our farm purchased a used 180K BTU output pellet boiler (Central Boiler Maxim 250) and two-ton hopper from a nearby farm. That spring we installed the boiler and set it up to be able to circulate water through 7 loops of pipe buried in the soil of one of our 30'x148' high tunnels. We also purchased a water to air heat exchanger and fan from another farm, which we installed be able to heat the air in the same tunnel using the same boiler. In the beginning of the 2018/2019 winter growing season, Becky Maden of UVM Extension helped us install soil and air temperature sensors and dataloggers in our heated tunnel, as well as in an adjacent tunnel of the same dimensions that was unheated. We hoped to get some data to begin to understand the effect that heating soil for winter production could have on the yield, timing, and profitability of growing winter greens in cold climates compared to an unheated tunnel. For winter production, we hoped to increase the overall profitability of our winter greens, and to increase production in the months of January and February, when slow regrowth limits our ability to meet market demand. Our farm has also tracked our summer yields and fuel use in our heated and unheated tunnels to understand how heating the soil and air for early summer production can affect profitability compared to an unheated tunnel. (Our farm does not utilize any other heat source in our tunnels, so this project is not able to comment on the profitability of heating soil compared to only using air heat for winter and early summer production.) This presentation will share the expenses of this project, as well as soil and air temperature data for winter and summer production, and some takeaways from our harvest and sales records from summer and winter tunnel production in heated and unheated tunnels.

System Design and Installation Cost: The boiler we purchased has a 90 gallon water tank, which it maintains at a temperature of about 180 degrees F. To avoid the risk of frozen water lines if the boiler were to break down in the winter, we filled the water tank with an antifreeze mixture to protect the lines to -20F. The boiler itself can hold about 500 pounds of pellets, and the hopper holds an additional 2 tons, which are augered into the hopper of the boiler. Hot water is pumped from the boiler through insulated pipe to a primary loop in the tunnel; if there is no call for heat then the hot water returns to the boiler with very little drop in temperature. If a thermostat calls for air heat, a solonoid valve opens that allows the hot water/antifreeze to be circulated through the water to air heat exchanger. We were reluctant to send antifreeze mix in pipes through the soil, in case a leak or punctured pipe would contaminate soil. Instead, a thermostat call for soil heat opens a valve that allows the hot antifreeze mix to run through a

water-to-water heat exchanger, which transfers the heat to a plumbing loop in which a separate circulator pump circulates water through the 7 loops of pipe buried 18" underground. A mixing valve limits the temperature of the hot water circulating through the soil to 110 degrees F. The total installation cost was about $13,000 in materials (about $3/sq ft), and about 80-100 hours of our own labor. Thank you to Chris Callahan of UVM Extension for technical assistance in system design.

Fuel usage and yield in heated/unheated tunnels: We planned on using the boiler to maintain a soil temperature of about 45 degrees F in the heated tunnel. The boiler was turned on in mid December, and it consumed 4.5 tons of pellets until late February, when there was enough warmth and sunlight to maintain a 45 degree soil temperature without adding heat. The BTU output was overkill for maintaining that soil temperature in a single tunnel, so I ended up charging the soil temperature a little higher, turning off the boiler until soil temperature dropped, and then firing up the boiler to recharge the soil temperature.

The warmer soil had a noticeable effect on the rate of growth in the tunnel, and we enjoyed faster regrowth in the coldest and darkest times of the year in comparison to the unheated tunnel. The greens in the heated tunnel were also less susceptible to damage from cold, although that winter was particularly mild and we experienced unusually little damage to greens in the unheated tunnel. The following table ranks the crop gross sales per bed foot in each tunnel. Rows with two crops in them are crops that are companion planted.

crop	tunnel	gross sales/foot
spinach/scallion	heated	27.42
baby lettuce	heated	26.56
parsley	heated	24.83
chard	heated	20.73
spinach/scallion	unheated	19.88
kale/baby lettuce	unheated	18.98
arugula	heated	16.56
choi	heated	14.39
Mustard greens mix	unheated	12.50
salanova	heated	11.54
Mustard greens mix	heated	11.43
cilantro	heated	9.04
choi	unheated	7.70

Some interesting takeaways are that mustard greens mix did not see an increase in gross sales/foot in the heated tunnel, whereas spinach/scallion did. This seems to be primarily because spinach and scallions have their primary harvest period late in the spring, and the heated tunnel increased their growth rate so that their primary harvest was pushed earlier, before the March/April glut of spinach. We were able to charge a premium as that spinach reached maturity in February, and were able to sell everything we could harvest. The spinach in our unheated tunnels, in contrast, matured later, when our tunnels and our markets were more saturated with spinach. Mustard greens mix grown in our system, on the other hand, has its biggest yield in the first cutting, with progressively smaller harvests on regrowth. So both the heated and unheated tunnels experienced their biggest harvest in December, giving no advantage to the heated tunnel. The mustard greens in the heated tunnel did regrow faster and finish maturity about 4 weeks earlier, but the overall yield was comparable in both. It's also of note that the top 5 highest grossing crops were grown in the heated tunnel (although we did not attempt to grow each of those crops in an unheated tunnel for comparison.) Similarly, the heated tunnel had some underperforming crops that can be subbed out in future years in favor of more profitable greens.

In this first season, total winter sales for the heated tunnel were $20,100 ($4.50/sq ft), and total winter sales for the unheated tunnel were $17,300 ($3.89/sq ft). The fuel cost for the heated tunnel was $1,075, so the profit margin heating a tunnel was fairly slim once depreciation on the heating infrastructure is taken into account. That said, the system does have a definite benefit of increasing the maturation of winter greens to allow for early plantings of summer vegetables in the heated tunnel. It is also promising to us to see some high performing crops grown in the heated tunnel, and also to see that last year's mix in the heated tunnel included some low performing crops that we will be able to hopefully replace with higher value winter greens in the future.

Our farm built another high tunnel this summer, and after reviewing the data we decided not to bury pipes in the new tunnel, even though the boiler would be capable of heating the soil in both tunnels over the winter. Our sense is that it may be possible to leverage the benefits of soil heat more than we did in the first season, but it is still expensive infrastructure to install, and maximizing the potential of warmer soil in the winter requires tight management. In short, I think that this technology can be utilized well and profitably on a vegetable farm, but it does not appear to be a guaranteed profit generator.

As this is being written, we're still crunching the summer production numbers to understand the value of soil heat in a year-round context. Please feel free to email if you have any questions.

Additional resources:

UVM biomass greenhouse heating project:
http://www.uvm.edu/vtvegandberry/Pubs/Greenhouse_Furnace_Project_Report.pdf

Root zone heating for greenhouses
https://farm-energy.extension.org/root-zone-heating-systems-for-greenhouses/

Tarping for Weed Control

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University of Maine Cooperative Extension: Highmoor Farm

Many small-scale farms have turned to reduced tillage practices in order to conserve soil quality, reduce labor costs and limit potential environmental degradation. Farmers adopting these practices are limiting the use and intensity of tillage by decreasing the frequency, depth or physical disruption of the soil. This has been especially challenging for organic growers who often use tillage as a primary source of weed control. While larger-scale conventional growers have traditionally moved towards herbicides in these systems, organic farmers are limited by the availability, cost and effectiveness of approved herbicide products and have looked for other methods. Tarping, while not a new practice, has gained much recent attention because of its potential in preparing seed beds and limiting weeds in these reduced tillage systems.

In collaboration with Cornell University, the University of Maine at Highmoor farm has carried out three different reduced tillage experiments involving the use of tarps since 2015. Key aspects of this research were to determine how tarping duration and tillage intensity after tarping affected weeds in recently established fields. Another focus was weed control with the use of tarps in a permanent bed system in combination with straw and compost mulch. The latter has evolved to include before tarping tillage at different intensities and is currently being executed. In our research we have found that tarps alter the soil environment, the presence of weeds and weed species composition.

Weed seed dormancy termination and germination requirements differ between species, but are influenced by soil chemistry, moisture, temperature and light. We have found that tarping influences these environmental characteristics by increasing inorganic nitrogen, conserving moisture, increasing temperature and excluding light. While the exact mechanisms go beyond the scope of this research; the exclusion of light is probably the greatest contributor to seedling death and the other characteristics likely play a role in germination or indirectly to seed death.

We have found that tarps applied for a duration of 3 weeks, 6 weeks, 10 weeks and over the winter create an area that is essentially weed free upon removal when compared to using no-tarp for spring and summer plantings (Figure 1). This leads to the possibility of eliminating an early season tillage to control weeds when using tarps and tillage in combination. This is also an easy, inexpensive and effective technique for controlling weeds in no-till on small scale farms. We also found that tarping for these times did not eliminate a winter killed oat cover crop. A positive implication of this is that the continued ground cover could work as a mulch and protect against soil erosion upon removal, a negative one being increased difficulty of planting and possibly cooler soil temperatures. However, both are dependent on the cover-crop's biomass.

We have also observed longer weed reduction benefits while using tarps up until harvest of spring (figure 2) and summer planted beets. However, we saw that the length of time that the tarps were on did not differ from each other. Different tillage intensities after the tarp durations

did not differ from each other as well. Furthermore, these treatments did not differ from shallow or deep tillage when not using tarps. Most interesting was the comparison between no-till at all tarp durations and the no-tarp treatments. No-till with tarps at all durations, controlled weeds as good as standard tillage practices. No-till with tarps also produced significantly lower weeds than no-till without tarps in this organic system.

We have also seen a noticeable shift in species composition and numbers when using tarps compared to not using tarps. In one of our trials, chickweed, clover, crabgrass and Canadian bluegrass which dominated our no-till plots were essentially eliminated using tarps. This promoted a shift to species typically seen in our disturbed ground such as lamb's quarter, shepherd's purse, pig weed and witchgrass. The implication of this is that tarps may work well to control specific problem weeds in organic no-till ground and perhaps may be able to reverse the typical shift to perennial weed species that is seen in no-till production.

Tarps are not the answer for every farm, but for those in organic systems who want to reduce tillage tarps could be a promising tool for weed management. The cost of tarps is low, the longevity is 5+ years, they are readily available and easily repurposed, making them a safe investment. However, results will vary depending on specific weed seed banks, soil environment and how and when the tarp is used on the farm.

Figure 1.

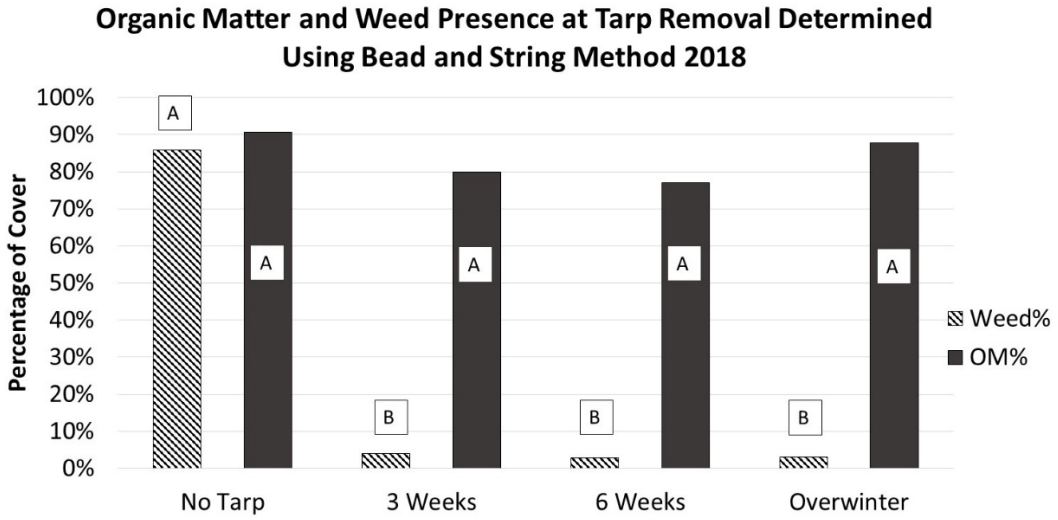

Figure 2.

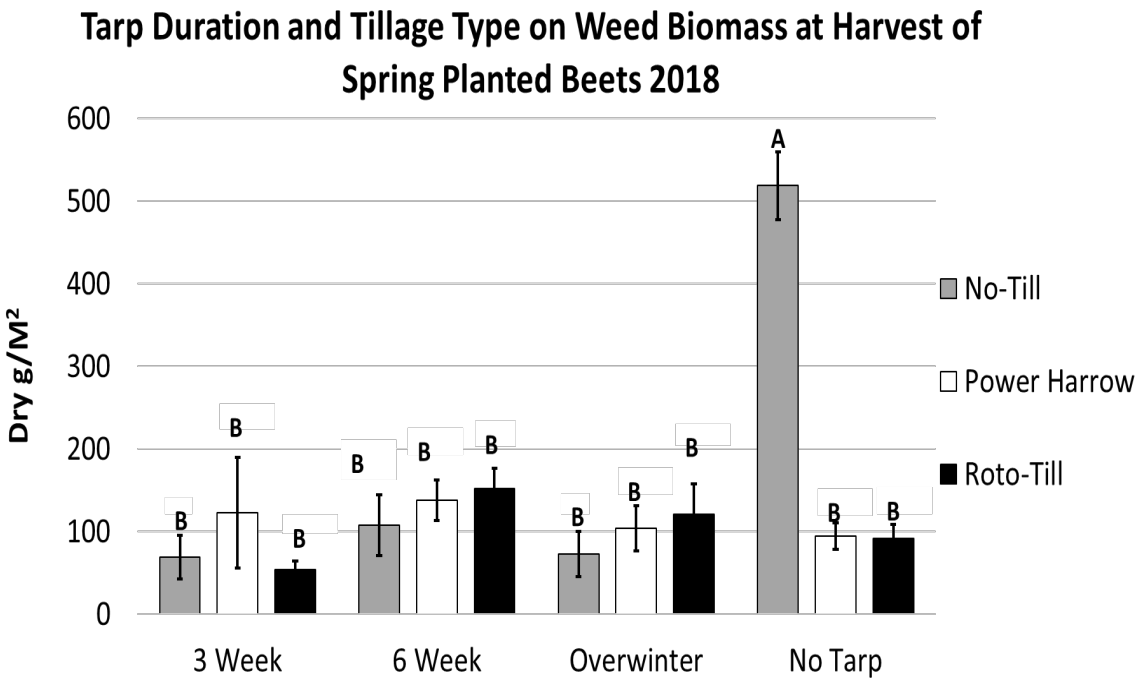
Tarp Duration and Tillage Type on Weed Biomass at Harvest of Spring Planted Beets 2018
Dry g/M²
600
500
400
300
200
100
0
A
B
3 Week
6 Week
Overwinter
No Tarp
No-Till
Power Harrow
Roto-Till

Table Grape Update

Dennis J Rak
Double A Vineyards Inc.

There are a large number of table grape varieties available to growers. Many of these are the old standbys and others are introductions that are more recent. I will review the old standards and give updates on new varieties from the University of Arkansas, Cornell and Elmer Swenson.

Cornell University	University of Arkansas	Elmer Swenson	Standby Varieties
Einset Seedless	Compassion	Somerset Seedless	Canadice
Everest Seedless	Faith	St. Theresa	Concord Seedless
Marquis	Gratitude		Himrod
	Hope		Lakemont
	Joy		Thomcord
	Jupiter		Vanessa
	Mars		
	Neptune		

Trellising and Training Systems

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Factors Influence the Choice of Trellis for a Vineyard

- Grape cultivar's growth habit
- Use of grape cultivar
- The expense of the trellis
- Productivity
- How well the trellis is adapted to mechanized operations versus labor availability
- The trellis's effect on vine balance

Grape Cultivar's Growth Habit

- Trailing growth habits versus upright growth habits
- Before you train vines to any system, consider the vine's growth habits to reduce labor needs and cost

Use of Grape Cultivar

- Juice or Wine
- Table grape
- Both

Expense of Choosing a Trellis

- Cost of materials
- Cost of installation
- Cost of annual maintenance
- Cost repair

Influence of the Trellis on Yield per Acre

- Amount of bearing surface of the vine per acre exposed to sunlight
- Single narrow row spacing may be nearly as productive as vineyards with wider row spacing and a horizontally divided trellis

Mechanized Operations versus Labor Availability

- Trellis's adaptability to mechanization
- Systems are more adaptable to mechanical operations than others
    - Pruning
    - Combing
    - Harvesting

Trellis's Effect on Vine Balance

Vine vigor potential significantly affects canopy management decisions and costs

- shoot thinning (disbudding)
- shoot positioning
- hedging

- lateral pulling
- leaf pulling
- removal of secondary crop
- crop thinning

Trellis Construction Basics

- Install before or after vines are planted
- Irrigation
- Drain Tile
- Wire Positions
- End-post Assemblies

Cane versus Spur Pruning

- Cane prune
  - Select two to four new fruiting canes per vine.
  - Cut back each of these to leave 8 to 15 buds per cane.
  - Leave a one- or two-bud spur cane near the fruiting cane with one or two buds each and these are "renewal spurs."
  - Remove all other one-year-old wood.
- Spur prune
  - Prune along main cordon to leave two-bud to five-bud spurs, each four to six inches apart.
  - Remove all other one-year-old wood.

Some Common Training Systems

- Low Cane
  - Vertical Shoot Position (VSP)
- High Wire Systems
  - Munson
  - Umbrella Kniffen
  - High-wire Cordon
  - Four-arm Kniffen
- Divided Canopies
  - Geneva Double Curtain

Vertical Shoot Position (VSP)

Advantages:

- Fruit can be situated relatively low to ground where it may benefit from radiant heat.
- Minimal vine structure makes it easy to cope with winter injury to vines.
- Long canes retain more fruitful nodes.
- Can be converted to a mid-wire spur (cordon) system.

Disadvantages:

- Difficulty in pruning & harvesting if low to ground.
- Possible congested fruit zone.
- Greater risk of spring freeze injury

Munson

Advantages:

- Fruit can be easily be seen
- Fruit cluster tend to develop better by hang down and open

- Long canes retain more fruitful nodes.
- Can be converted to a high-wire spur (cordon) system.

Disadvantages:

- Difficulty in pruning & harvesting working over shoulder height
- More complex trellis

Umbrella Kniffen

Advantages:

- Easy to learn system.
- Fruit high, distributed and well exposed.
- Simple trellis construction.

Disadvantages:

- Requires of annual tying of canes.
- Less adaptable to shoot positioning.

High-wire Cordon

Advantages:

- Adaptable to mechanical pruning, unskilled manual pruning, and mechanical shoot positioning.
- Fruit are high for good sun exposure.
- Requires little annual tying.

Disadvantages:

- Tends to reduce vine vigor, especially if shoots are positioned.
- Difficult to establish cordons where there is frequent winter injury.
- Old cordons hard to remove from wires.
- Old cordons may become a reservoir for diseases

Four Cane Kniffen

Advantages

- Ease of pruning to long canes.
- Vertical distribution of fruit.
- More compatible with tolerating winter injury than cordon systems.

Disadvantages

- Requires annual tying of canes.
- Difficult to maintain quality on lower wires (shading).
- Not compatible with systematic leaf removal & shoot positioning.
- Low wire fruit zone is lower to the ground

Geneva Double Curtain

Advantages:

- Method to handle high vigor vines.

Disadvantages:

- Requires additional labor to shoot position.
- Difficulty in pruning & harvesting working over shoulder height
- More complex trellis

Trellis Systems Common Elements:

- Posts
- Wire
- Anchor/Bracing

Posts

- Wood
  - Drive Posts (augered holes not preferred)
  - Typically – line three to four-inch diameter, eight feet long, pressure-treated, most common pine/lodgepole pine
  - Line posts – two feet in ground, remainder above
  - Twenty-four feet between posts
  - All post same height
  - End post min five to six-inch diameter with three feet in ground
  - Should be angled out – up to 60 degree angled for dead-man brace
- Steel
  - Problem with wind
  - Consider wood post every 3 to 5 posts
- Concrete
  - No experience

Anchor/Bracing

- Dead-Man Anchors
  - Screw in anchor (augur anchors)
  - Pound Post Anchor
    - Seven feet post with four feet in ground and three feet above ground
    - Can be seen by equipment operators
  - Duck bill type
- Angled In-Row Brace
  - Brace should be twice the height of end post
  - Slight angled 10 degrees to Vertical
- H-Brace
  - Height should be half of the brace length (4’ for 8’ long brace)
  - Wire bottom of end post to brace height of in-line post

Wire

- Standard – 12.5-gauge high tensile steel (or larger)
- Remember – wire is wound under tension – can be dangerous
- Use spinning jenny
- Splice correctly
- Leave enough length at ends of row to work with
- Poly or monofilament wire stretches is advantage and disadvantage, pruning can cut wire is disadvantage
- Tie-offs
  - Compression Sleeve
  - Gripples - Crimp correctly
  - Double wire wrap with staple
- Strainers – only need on wire carrying fruit loads
  - In-line ratchet
  - On-line with tool with tighten tool

Fasteners

- Staples for wood post use 1.75-inch or 2-inch long, 8- or 9-gauge, hot-dipped, galvanized staples
    - Right-hand staple - top of staple angled to right 30 to 45 degrees and the opposite for left-hand staple
    - Don’t drive tight
    - Top wire on top post is okay
    - I do NOT like wire through post – cannot move the wires!
- Proprietary fasteners for steel or concrete
    - Pre-bent wires and clips
    - Some post has pre-formed wire slots – be careful of uniform height of post

Catch Wires

- 12.5 gauge but can 14 gauge
- Fastening end are problem
- Use strainers
- Does not have to be same tension on crop supporting wires

Support arms

- Munson or Geneva Double Curtain
- Pressure treated 2x4 board with support steel or wooden

Invasive Pests that Affect Grapes (SWD, BMSB and SLF)

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Spotted wing drosophila (SWD), *Drosophila suzukii* Matsumura (Diptera: Drosophilidae), lays its eggs in the fruit of a broad spectrum of wild and cultivated host plants. This fruit fly differs from its native relatives in that it lays its eggs in ripening fruit on the plant, rather than previously damaged or rotting fruit. The result of this behavior leads to crop loss when feeding from developing larvae cause the ripening fruit to "melt" off the plant. This behavior also leads to post-harvest issues, when otherwise marketable fruit contain microscopic SWD eggs. If fruit are not refrigerated, larval feeding will lead to fruit "melting" on fruit stands or on customer counters.

While SWD is a serious pest of brambles, blueberry, cherry, and day-neutral strawberry, the pest status of SWD in table grapes is controversial. Egg-laying by SWD has been demonstrated to be possible in table grapes, but rare. As with native species of fruit flies, SWD are certainly "nuisance" pests and can become "secondary" pests following fruit cracking due to abiotic and biotic causes. Both native fruit flies and SWD can create more severe sour rot disease outbreaks in winegrape production, but the role of fruit flies in disease severity of table grapes is unclear.

Brown marmorated stinkbug (BMSB), *Halyomorpha halys* Stal (Hemiptera: Pentatomidae), feeds on the seeds and fruits of a broad spectrum of wild and cultivated hosts. Both nymphs and adults cause piercing-sucking damage, which can cause crop loss when it occurs early in the development of fruits, or cause reduction in crop quality by distorting the appearance of fruit. This stinkbug differs from its native relatives in terms of population growth potential and its inclination for overwintering inside people's homes or other man-made structures. BMSB has been present in northeastern states for several years, but rarely reaches populations that cause serious injury to horticultural crops.

While BMSB injury has been reported in New England sweet corn, pepper, and apple production in the past few years, risk of crop injury to table grapes is likely negligible in the northeast. Even when BMSB populations have reached economically-threatening levels in our region, this occurs late in the season before feeding can lead to crop loss. Post-harvest issues may be of concern, as BMSB adults are often found in harvested fruit and can potentially make their way to market. These insects are large, and the odors associated with these aptly-named stinkbugs can be off-putting. "Stinkbug taint" has been a marginal concern for winemakers, but concerns for table grape growers is unclear.

Spotted lanternfly (SLF), *Lycorma delicatula* White (Hemiptera: Fulgoridae), feeds on the stems and trunks of a broad spectrum of wild and cultivated host plants. This planthopper feeds on plant sap using piercing-sucking mouthparts, and large aggregations of SLF can cause plant

decline and sooty mold on vine or trunks, and eventually lead to plant death. Outbreak populations are affecting agricultural and landscape plant production in areas of Pennsylvania and Virginia, and its presence has been detected in Maryland, Delaware, New Jersey, New York, and Connecticut. Regulatory and quarantine efforts are currently in place to prevent or slow the spread of this insect, and to detect its arrival in unreported areas.

While the pest status of this relatively new invasive insect remains unclear in many commodities, grape production is clearly at risk of crop loss. Vine death due to SLF outbreaks has been reported in areas of Pennsylvania. This is insect is large and outbreak populations are particularly conspicuous, so identifying best practices for monitoring will likely not be necessary. Additionally, affected growers report easy control of this pest. Best management for outbreak populations currently relies on neonicotinoid products such as Venom, Actara, and Assail, but acceptable control can be achieved using contact poisons such as Sevin, Malathion, and Imidan. Organic options include insecticidal soaps, sulfur, and pyrethrums.

Growing Table Grapes on Our Farm

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In 2007 University of Massachusetts Extension planted a trail plot of seedless table grapes on our family farm. The trail plot consisted of 20 each of Marquis, Mars, and Vanessa. As the vines matured and fruited we saw that the fruit had potential for wholesale and farmstand sales. In the following years we increased plantings to approx. 3 acres. Our main varieties are Mars, Summerset, Jupiter, Marquis and Vanessa. Vines are planted 8 feet in row and 10 feet between rows. The cordons are trained to a wire 5 feet above ground. Posts extend another two feet above this enabling us to put up netting for bird control. Ground vegetation is controlled with herbicide and mowing. The vines are sprayed to control disease and insect pests. The main diseases being powdery mildew, black rot and bunch rot. The main insect pests are Japanese beetle and Grape Berry Moth. Spotted wing drosophila (SWD) is only a problem if the berries are damaged, cracking being the main source of entry point. Vines are pruned in early spring. After bloom fruit clusters are thinned and new growth combed. Mid-summer new growth is tipped to keep driveways open for mowing and spraying. A few weeks before harvest side leaves are removed to expose clusters to the sun. The leaves above the clusters are left for shade. We expect to achieve approximately 4.5 tons per acre on the three acres. This year's Mars yielded 7 tons on ¾ an acre with very little damage.

Wholesale sales have been good netting around $4,000 per acre. Our own retail market has done very well with enthusiastic sales and feedback from customers. By far the biggest cost for wholesale is labor. Packing for wholesale is time consuming. Clusters must be inspected for any damaged berries and removed. Each package must be weighted to ensure 12oz. Currently we are getting $36 for a flat of 16 12oz packages, which works out to $3 a pound. We have an increasing bulk market at $2.50 a pound, that does not require such detailed inspection as wholesale and without costly packaging. Grapes sold on our retail stand bring $5 a pound. Grapes store well in cold storage, provided humidity is high. We expect good quality for up to 45 days in storage.

Observations regarding varieties: Mars by far gives the best return year after year due to its cold hardiness; birds leave it alone and cracking has not been of significance. Marquis and Vanessa are not as cold hardy, but have given descent crops year after year. Sumerset is extremely productive but very susceptible to cracking. It has a tight cluster making it impossible to find all the damaged berries. SWD is a problem due to cracking with this variety. The eating quality is excellent and it stays good on the vine for a long time. We will try calcium sprays in the future to see if this will help. Irrigation keeping soil moisture level consistent is another potential remedy. Sumerset is the first variety to ripen and has good sales potential provided we can solve the cracking problem. Another issue with Sumerset is the birds love it. We have netted them, which solves the problem, but adds to cost. In 2017 squirrels cleaned off the whole crop despite netting; an unusually bad year for squirrels! They have not been a problem since. Jupiter is a very nice

variety but must not be allowed to over set. Berries will not color well and cluster shattering will be a problem as you wait for color. If the crop load is managed properly it is a very good grape. We have Einset, Thomcord, and Venus in small numbers as trials and are most excited about Einset. It is a big hit on our stand and has born every year with consistency.

Conclusions: I enjoy growing grapes but am unlikely to plant more for wholesale. They work well with our retail stand generating excitement with our customers. Our biggest challenge is figuring out how to reduce labor costs. I believe we can improve summer pruning efficiencies with better training. Reducing berry cracking will go a long way toward reducing packing costs. Get your netting on early! Birds will be a problem at first hint of color! And, pray the squirrel population stays in check!

Pruning and Renovating Blueberry Bushes

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Regular pruning is an essential component of blueberry management, yet its importance is often underestimated because the costs to the neglectful grower are not immediate. Regular pruning is required to maintain the vigor and productivity of bushes over time, to aid in disease and insect management, to maintain large fruit size and quality, and to develop an appropriate growth habit for harvesting.

A young blueberry plant will produce many canes for the first several years. Over time, cane production will gradually slow as bushes become tall and canes age. Yields will decrease eventually because of the absence of new growth on which flower buds form. An increasing amount of leaf area will be required to satisfy the increasing respirational demands of both the fruit and wood. Furthermore, light penetration into the canopy will diminish, resulting in a shift of fruit production to the exterior of the bush, causing a decrease in bearing surface. Appropriate pruning practices can maintain a blueberry bush in an efficient and productive state without the detrimental changes described.

Pruning young bushes

Very little pruning is required until plants are about 8 years of age. Before then, the rule of thumb is to remove anything that is diseased, damaged or dying. After that, intentional cane removal is practiced.

Remove flower buds for the first two years to promote vegetative growth. This can be achieved by rubbing off the fruit buds, or by pruning the tips of shoots where the flower buds are located. At the beginning of the third year, remove any twisted or low-growing canes to promote new cane production, or those that are diseased, damaged or dead.

If more than two new canes were produced the previous year, remove all but two or three of the healthiest at the crown level. In subsequent years, continue light pruning until the plants reach full size, removing all but 2 or 3 of last season's canes. When plants are about 8 years old, they should contain between 10 and 20 canes of many different ages. Some cultivars produce many more canes than others, so the amount of pruning that is required on young bushes will vary with cultivar.

Selecting canes for removal in mature bushes

When selecting canes for removal, first look for any winter-injured or broken canes, or canes with disease and insect damage. If injury is severe, remove that particular cane. Cankers and scales are common pests that can be partially controlled through pruning. Second, remove any cane that is rubbing against another to prevent canker infections. Third, remove those that

are interfering with movement through the alley. Aim for a plant with an upright growth habit, yet with a sufficiently open canopy to allow for light penetration. Mechanically harvested bushes should be trained to a more upright habit and narrower crown than those that are hand harvested. Finally, remove short, branched canes that never receive much light. If these canes produce fruit, it will ripen late and will rarely be harvested.

At about 8 years, individual canes start to lose their productivity as more leaves are required to support a given amount of fruit on those canes. Typically, these 8-year-old canes are about 1.25 inches in diameter. In addition, canes have branched considerably by then, and the most recent growth on which flowers form is usually thin and weak. Removing two or three of the largest canes in a mature bush will promote new cane growth and eliminate the less productive older canes. If bushes contain a mixture of canes of different ages, then annual removal of canes that have reached 8 years of age will allow for a minimal reduction in productivity as 7-year-old canes grow to replace those that were removed. Judgment is required since removing too many canes can result in lower yield. Studies have shown, however, that up to 20% of the basal area of a bush can be removed without impacting yield because the remaining fruit will become larger.

Care should be taken to remove canes as close to the crown as possible. Do not leave 6 to 8 inch stubs. These will rot, act as a source of disease inoculum, and will not regenerate new shoots.

Time of pruning

Early spring is the best time to prune blueberries. Although some growers begin pruning immediately after harvest, it is thought that this makes plants more susceptible to winter injury and reduces the long-term productivity of bushes. By pruning in early spring after the snow melts, one can identify winter-injured wood and remove it, plus cut off the canes close to the crown. Carbohydrates produced in autumn will also have had sufficient time to move into the roots and crown for storage.

Regularity of pruning

Annual pruning is essential for stable production and high productivity. When bushes are pruned irregularly, young canes are produced in great numbers the year after heavy pruning. These canes will age together, and become unproductive at the same time. If one then wants to prune out the unproductive canes, nearly the entire bush will have to be removed. Also, no young growth is present to make up for the loss of fruiting wood. Therefore, irregular pruning results in erratic yields from year to year, and bushes will get too tall as individual canes elongate to compete for light. Research has shown that annual, moderate pruning produces bushes with the fewest canes, but with the greatest yields.

Detailed pruning

Removing injured wood should be the primary objective of detailed branch pruning in the tops of the canes. Branch pruning can result in higher fruit quality because berry numbers are

reduced. But if one has done a good job removing whole canes, then little detailed pruning will be required and it may not be worth the investment of time.

Weak bushes may require more pruning than vigorous bushes because pruning stimulates vegetative growth. Also, special consideration must be given varieties with spreading habits. Sprawling canes should be removed, but care should be taken to leave sufficient canes for fruiting.

Rejuvenation

When rejuvenating an old planting, remove one or two old canes for every five or six younger canes. In following years, remove 20% - 30% of the wood until new cane growth occurs. Keep only 2 or 3 new canes and continue to remove the oldest canes. Eventually, the bush will become more productive, cane numbers will decrease, and bush stature will decline.

In old, poorly maintained plantings, some growers have had success cutting all the canes to ground level; harvesting begins 3 years later. However, for this system to be most effective, canes must be thinned to the most vigorous 6 – 10 and then closely manage cane growth after that. Others find that summer hedging immediately after harvest, coupled with selective dormant cane removal, works well.

Summary

Pruning is an investment in the future productivity of the blueberry planting. Regular annual pruning will spread costs throughout the life of the planting, ensure stable production from year to year, and serve as a useful tool for managing pests, fruit load, and quality.

Sharing Feedback on Blueberry Varieties – Discussion

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Growers know which varieties work for them, and while conditions and priorities differ for every farm, it's helpful to know what varieties other growers like and which ones they wished they never planted. At this session we will have an open discussion about blueberry varieties - which ones you like, which ones you don't like and why. After talking to 12 commercial blueberry growers from RI and MA in the summer of 2019 below is what I heard.

> **Blueberry varieties priority key:** Each + is one farm that liked the variety; each **-** is one farm that didn't like the variety. **+/-** means one grower liked it, but had problems with it. Results from survey of 12 commercial growers in RI & MA:

Favorites

Bluecrop +++++++

Very firm berries. Good! Easy to grow and productive. 2019 had a lot of Phomopsis cane blight. Need to trellis or flops over.

Chandler ++++

Nicest berry. Good flavor, ripens one at a time over long period. Good for PYO. Unique bush-type growth. Big berries. Not acidic. Doesn't send up canes well.

Earliblue +++

Good flavor.

Blueray + + + + -

Good berry that's early. Resilient plant. Nice, but not as firm as Bluecrop. Ripens about one week after Bluecrop. Hard to prune.

Duke ++ +/-

Big berry, early, good flavor. Early season. Some plants died after planting.

Jersey ++

Good size and flavor. Very reliable.

Nelson ++

Good, berries bigger than Jersey. Pick into September.

Spartan ++

Largest berry. Get winter dieback but still produces every year. Early season.

Legacy +

Big berries that stay firm. Good flavor. Customers' favorite. Michigan variety.

Bonus +

Big berry, flavor OK.

Mixed blessings

Berkeley + + - -

Easy to pick, good flavor. Customers' favorite. Pretty light blue color. Large berry. Small berries. One grower plans to rip out all his Berkely because plants too tall and weak.

Liberty +/-

Good berries, but bushes not vigorous.

Collins + -

Good flavor and early so miss SWD. People won't pick if other blues available.

Wish never planted:

Elliot - - - -

Stems stay on, too sour**.**

Corville - -

Too late. Get first picking, but that is it.

Patriot -

Sour.

Reka -

Not much sugar.

Late Blue -

Never seem to ripen and not enough sugar.

Chemical Control for Spotted Wing Drosophila

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Short generation time and high fecundity makes management of spotted wing drosophila (SWD) challenging in susceptible fruit crops, and increases the likelihood of eventual evolution of insecticide resistance. Research and extension fruit entomologists across the country have demonstrated that blueberries can be protected from significant infestation by SWD with insecticides if (1) they are applied at the start of ripening until the end of harvest, (2) the most effective insecticides are used, (3) insecticides are applied on approximately a weekly basis, and (4) insecticides are reapplied after rain events exceeding half of an inch. This strategy has largely emphasized insecticide products that kill adult flies. For blueberries, the most useful and effective products [the preharvest interval is in brackets; only those with PHI less than 5 days are mentioned] are insecticides in the pyrethroid (e.g., Mustang Max [1], Danitol [3], Bifenture or Brigade [1]), organophosphate (Malathion [1], Imidan [3]), carbamate (Lannate [3]), spinosyn (Delegate [3], Entrust [3]) and diamide (Exirel [3]) classes. With the exception of the spinosyns and diamide insecticides, these insecticides can be anticipated to have significant non-target impacts on beneficial insects, and so we can anticipate greater problems with aphids (and the viruses they vector) and Putnam scales under a more aggressive spray program directed to manage SWD. A thorough review of the state of knowledge regarding conventional insecticides and SWD management are available at: https://www.youtube.com/watch?v=nV4Yb6_DiHw. Organic growers have limited options and need to consider multiple non-insecticidal management options along with insecticides (see https://eorganic.info/spottedwingorganic). Organically acceptable insecticides with some efficacy include Entrust, Pyganic, Azera, Grandevo, and Venerate. Note that the number of consecutive and total applications of Entrust to a crop and on a farm are limited by the label in an effort to prevent insecticide resistance.

Translaminar or truly systemic insecticides can be more effective against SWD than tests against adults may indicate. Products with these properties include the neonicotinoids (Assail [1], Actara [3], Admire Pro [3]), Lannate, Exirel, and Delegate/Entrust. Interruption of larval development may be a potent mechanism for protecting fruit from detectable injury. Similarly, insect growth regulators (e.g., Rimon [8], which causes infertility in adult flies) may be undervalued because conventional insecticide assessments underestimate their impact. Its longer PHI may not preclude Rimon from being useful, as it must be applied in advance of egg laying to be effective, and so should be used when fruit are too firm for oviposition to take place.

Including a small quantity of table sugar (2 lb per 100 gal. of spray mix) as an adjuvant with most insecticides (except pyrethroids) does improve their performance. Rodriguez-Saona's experiments in blueberries demonstrated that a reduced impact spray program (rotation of Assail and Delegate), when combined with sucrose was equivalent or slightly better than a program using conventional products (rotation of Bifenture and Imidan), but performed poorer when not combined with sugar.

Generally, field trials testing this approach have seen some benefit when mixing sugar with Imidan, Entrust, Assail, and Delegate/Entrust. It is important to use this low rate of sugar, which can trigger feeding responses in SWD but should go unnoticed by bees.

A twist on the use of sucrose as a spray adjuvant to stimulate feeding will be to substitute a 4:1 ratio of erythritol (a four-carbon non-caloric natural sweetener) and sucrose (e.g., use 2 lb of erythritol + 0.5 lb of sucrose in 100 gal. of insecticide spray). Several researchers have found that erythritol has inherently insecticidal effects against *Drosophila* spp., and SWD is no exception. Several mechanisms could be involved, but the strongest evidence is that (1) erythritol tastes sweet and is readily consumed by SWD adults, (2) the erythritol is readily absorbed into the hemolymph from the gut, but (3) the erythritol is not excreted by these flies. Therefore, a high blood sugar condition (analogous to a diabetic condition) causes disruption of normal physiology (feeding and laying eggs), and results in death. Although common food items (sugar and erythritol) are exempt from tolerance on food crops, their use to combat SWD is based upon the premise that they are being applied as adjuvants, and not directly as insecticides. Otherwise, applying them to a crop as an insecticide would require that they be registered by the U.S. EPA as a pesticide. Although the erythritol + sugar combination could be an organically acceptable SWD insecticide, registration of such a product may not happen, because these ingredients are readily available and are relatively inexpensive.

In summary, effective management of SWD with insecticides does not have to rely upon broad-spectrum organophosphates, carbamates, and pyrethroids that have high environmental costs, such as disruption of natural enemies and toxicity to birds and fish. Rather, an improved IPM-compatible program can be designed to target multiple SWD life stages while minimizing non-target impacts. An example would be to disrupt viability of eggs with a Rimon application nine days before first harvest. Through the period during which fruit are ripe, three lower ecological impact insecticides (Assail, Entrust/Delegate, and Exirel) can be used in rotation. In contrast to most broad-spectrum insecticides, these three insecticides not only kill adult SWD, they may also kill newly hatched larvae in fruits. Finally, erythritol + sugar could be used as an adjuvant with all of these products to further disrupt egg laying and to shorten the flies' life expectancy.

Mentions of a trade name is for convenience only and does not constitute an endorsement of that specific product. Always read and follow label instructions.

Review and Update on Blueberry Diseases

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In 2018, a total of 89,200 acres of blueberries are harvested with a production of 562 million pounds. Several diseases impact blueberry cultivation in the Northeast. Through this talk I will provide an overview of economically important high bush blueberry diseases, scouting, symptoms and management strategies.

a. Mummy berry, caused by the fungal pathogen *Monilinia vaccinia-corymbosi.*

Symptoms and signs:

- Attacks new growth, blossoms, foliage and fruits. Cup-shaped structures called apothecia are formed in spring. Apothecia produce spores that infect young tissue and cause rapid wilting; resulting in leaf and twig blight or shoot blight symptoms.
- Infected fruit becomes malformed, turn salmon-colored or grey by midsummer. By fall, these fruit drop to the ground, turn to mummies which produce apothecia the next spring.

Management:

- Select disease resistant cultivars. Make sure planting material is healthy and disease-free. Reduce inoculum levels by hand picking or raking of mummies or covering mummies with a 2-inches layer of thick mulch or application of 50% urea prills in the spring destroy mummies. Several fungicides are labelled for use for this disease.

b. Botrytis blight/ Gray mold, caused by the fungal pathogen *Botrytis cinerea*

Symptoms and signs:

- Affects blossoms and developing fruit. Bloom is the most critical period of infection. Rotted berries typically have a gray cast of the mycelium and spore-bearing structures present which gives the disease its name.

Management:

- Select disease resistant cultivars. This disease gets severe if cool, wet periods last several days during bloom; excess nitrogen is used; under poor air circulation and when blossoms are injured by frost.
- If weather conditions are congenial for disease occurrence and field has a history of this disease, fungicides should be applied, starting at mid- bloom, with subsequent sprays at 7-10 day intervals through petal fall.

c. Anthracnose, caused by the fungal pathogen *Colletotrichum acutatum*

Symptoms and signs:

- This fungus primarily damages fruit but may also infect twigs and spurs. It causes a salmon-colored berry rot and ruin fruit quality. Infected fruit exhibit a soft, sunken area near the calyx-end. Infected blossom clusters turn brown or black. Infected fruit show salmon-colored spore masses at the blossom end.
- Stem cankers with raised purple margins are rare, but are about 1/8" in diameter if present. Young girdled stems die back, resulting in a brown withering of leaves.
-

Management:

- Select disease resistant cultivars. Pruning and cleaning for optimal air circulation are beneficial for anthracnose management. Several fungicides are labelled for this disease.

d. Fusicoccum Canker or Godronia Canker, caused by the fungal pathogen *Godronia cassandrae*

Symptoms and signs:

- *This pathogen* infects blueberry stems causing dieback and plant decline. Symptoms are similar to Phomopsis canker. The most unique symptom is a red-maroon-brown lesion centered around a leaf scar, resulting in a bullseye pattern. As the lesion enlarges, the margin remains red and the center turns gray and dies. On young (1-2 year old) stems, extensive stem infections quickly lead to flagging and dieback of the entire stem. Wilting and death of shots as a result of stem girdling is another symptom.

Management:

- Select disease resistant cultivars. Sanitation is essential. Apply fungicides at 2-week intervals from late dormancy to petal fall if disease incidence is high.

e. Phomopsis Twig Blight, caused by the fungal pathogen *Phomopsis vaccinii*

Symptoms and signs:

- Symptoms first appear on smaller twigs and spread into larger branches and may affect the crown. The pathogen may spread downward in injured canes to the crown and then progress upward on new canes.
- Younger tissue may show no symptoms at first and then exhibit rapid wilting and dieback. Stem lesions are similar to those caused by Fusicoccum but lack the bullseye pattern. This disease causes premature ripening of the berries.

Management:

- Select resistant cultivars. Avoid mechanical damage, drought stress and fertilization after July 1st. Several fungicides are labelled for this disease.

f. Phytophthora Root Rot, caused by the fungal pathogen *Phytophthora cinnamomi*

Symptoms and signs:

- This disease is usually associated with poorly drained areas in a field and gets worse in plants that are grown in heavy clay soils. Roots of infected plants get discolored. Under high disease pressure, the entire root system is reduced in stature and is totally black.
- Above-ground symptoms include chlorosis and reddening of the leaves, smaller leaves, defoliation, death of branches or entire canes, stunting, and death of the entire bush.

Management:

- The disease is best avoided through careful site selection. Water logging conditions should be avoided. Most varieties are susceptible to the disease, although some varieties may better tolerate infections. Fungicides are labelled for this disease.

g. Blueberry Stunt, caused by a mycoplasma-like organism or phytoplasma and spread mainly by the sharp-nosed leafhopper.

Symptoms and signs:

- Symptoms vary with the stage of growth, time of year, age of infection, and variety. Affected plants are dwarfed with shortened internodes, excessively branched, low in vigor with small

downward cupped leaves which turn yellow along the margins, and between the lateral veins, giving a green and yellow mottled appearance.

- Mottled areas will turn brilliant red prematurely in late summer, although the midrib remains a dark bluish-green. Fruits on infected bushes are small, hard, lack flavor, ripen late if at all, and remain attached to infected plants much longer than they would on healthy plants.

Management:

- Select disease resistant cultivars. Once infected, the disease cannot be cured. Infected plants should be sprayed with an appropriate insecticide and removed from the field as soon as a diagnosis is made.

h. Blueberry Red Ringspot, caused by the blueberry red ringspot virus (BRRSV).

Symptoms and signs:

- Symptoms of this disease are very distinctive, including red spots, rings and oak-leaf patterns which usually appear on the older leaves in late June or July. Fruit production is seriously reduced and berries become pockmarked and unattractive.

Management:

- Select disease resistant cultivars. Once infected, the disease cannot be cured. Infected plants should be removed promptly.

i. Blueberry Mosaic, caused by blueberry mosaic virus (BlMaV).

Symptoms and signs:

- Infected plants become unproductive. Leaves are brilliantly mottled with yellow, yellow-green and pink areas. Not all leaves show symptoms and some branches on an affected bush may be symptomless. It may take several years for a bush to show symptoms.

Management:

- Select disease resistant cultivars. Once infected, the disease cannot be cured. Infected plants should be removed promptly.

Further Reading:

Caruso, F. L. and Ramsdell, D. C. 1995. Compendium of Blueberry and Cranberry Diseases. APS Press. St. Paul, MN. 87 p.

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Cleaning Your Wash/Pack Equipment

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As we learn more about reducing microbial risk on the produce farm, more emphasis is being placed on cleaning food contact surfaces and adjacent areas. Accessing the hard to reach spaces in wash line equipment is challenging. Most of the equipment was not made to come apart very easily or in an economically efficient manner. Our research focused on figuring out approaches to cleaning and sanitizing that can get the job done. The trick is to be able to do an effective job in an efficient manner. Time is money and the results indicated a balance is needed between the thoroughness of best management practices for reducing risk while keeping an eye on the cost. The results will be discussed at this presentation where "reasonable" management practices will be discussed.

The equipment in the study was a commonly used combination set-up consisting of a belt conveyor connected to a brush washer feeding onto a foam donut water "absorber" or dryer. We also looked at a wooden root barrel washer. We examined a number of methods of getting "dirty" equipment clean. The first step was determining how vegetable matter crud gets spread around. The second step was to determine what tools did a decent job getting into hard to reach areas and for removing cruds from various surfaces. Thirdly, we needed to figure on how "clean" was clean. Was our eyesight that good? How could this be tested? Once methods were identified it was important to factor in the time it took to reach "clean". A cleaning "checklist was created for the conveyor brush washer combination set up and one for the root barrel washer. SOPs for other aspects of wash/pack facilities fixtures were also made.

Reasonably clean means a good deal of scrubbing, reaching into hard to reach spaces, keeping to a cleaning regiment dedicated to doing the job correctly. Reducing microbial contamination isn't easy. Research conducted at UMass has indicated on the microbial level it is near impossible to reach 100% clean (bacteria-free). Therefore, our best approach is being able to remove as much of the food source for bacteria as possible, removing the moisture, and reducing the opportunities for introduced contamination.

In the end, there were two approaches needed for any equipment that has been used for washing produce. The first is the thorough cleaning. The second is maintenance cleaning. Using the combination of these will go a long way to being ahead of the cleaning game.

Thorough cleaning consists of disconnecting equipment from each other or from work tables. Where possible, take apart pieces as noted in the checklist (and on the narrated presentations found on our website). The tools used are listed and methods of cleaning outlined. This thorough cleaning takes time (3-4 hrs+). Our recommendation is that it should be done in the off-season but ideally as soon as the harvest season is over.

Dedicated water hoses kept off the floor with a thin wand/nozzle for rinsing and a dedicated pump sprayer is useful. Use detergent in the sprayer. Scrub out where ever you can reach.

Remove conveyor belt, set up brush washer on its side (same with absorber). Rinse again with water. Once clean spray down with sanitizer. Keep the equipment covered to prevent accidental contamination.

When the harvest season starts, the equipment will be clean and ready to go. The maintenance cleaning should be done daily. This consists of rinsing off fresh debris before it dries on. Use a dedicated water hose attached with a thin wand and spray nozzle. Spray down the food contact surfaces and down into areas where debris can fall back onto food contact surfaces.

The checklist provided here has been developed through hands-on research cleaning equipment as thoroughly as can be measured without doing microbial testing. From our work, the level of cleanliness provided here appears to be sufficient. Critical cleaning points are identified. Use bright flash light to see into dark areas. Flexible handled mirrors may also be necessary. Once cleaned, use appropriate sanitizer following label directions. Dry off equipment using a fan. This could take several hours. Bacteria doesn't grow without moisture.

Similarly, the root barrel washer also can follow the thorough/maintenance cleaning method. Starting the season with a thoroughly clean piece of equipment makes the maintenance cleaning more effective. Wooden barrel washers don't appear to be that complicated to clean. Upon closer inspection, see where all the spaces where vegetable crud can hide and accumulate. There are cracks and checks in the wooden planks. Screw heads. Exposed screw and bolt threads. Spaces between barrel staves. Corners. Motor drive chain. Spaces under the metal barrel bands. On water spray pipes. See the checklist for the complete inspection listing. Rinse off with water, use detergent mixed with water for scrubbing off crud (assume tiny particles are present even if you can't see them if the wood hasn't been cleaned after each use). Follow up with rinsing then a sanitizer. Dry off equipment with a fan.

The informational resources mentioned (along with other resources) are available on the Cornell Vegetable Team's website: cvp.cce.cornell.edu under the Food Safety banner.

Farming in Oklahoma is not that Different than New England:
I can Represent us both on the NOSB

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Emily Oakley and Mike Appel co-own and operate Three Springs Farm, a diversified certified-organic vegetable and fruit farm in eastern Oklahoma. Emily is an Oklahoma native, and Mike is from New York. After interning and attending graduate school, we moved to Oklahoma in 2004 and jumped into farming. Our first three years were on leased land on the outskirts of Tulsa. During that time, we looked at over 150 properties. Oklahoma is not widely blessed with good soils, and it is too far south for glacial deposits. In the fall of 2006, we finally found a property that had decent soil and an ample supply of water. We now own 21 acres in Cherokee County along one of the most pristine creeks in the state.

Farming is our full-time occupation. We are a two-person operation except for an amazing volunteer who works with us on our two harvest days. Our gross annual sales are typically over $100,000, and our expenses are usually around $25,000. Our marketing season is from the beginning of April to the Labor Day (21-22 weeks). We don't sow a fall or winter cash crop, instead putting the land into a fall/winter cover crop and fallow period.

We grow over thirty different crops on four acres of cultivated land. However, not all cultivated land is used to grow cash crops at any given time. At the most, two and a half acres will be under production while the remaining land will be in cover crops. Half of our four acres of tilled land is in cover crops for nine months of the year. The other half is cover croped for seven months of the year. We grow two main mixes of cover crops. In the fall we plant oats, vetch, tillage radish, and clover. The oats and radish are winter killed, but the vetch and clover survive the cold and create a lush leguminous cover in the early spring. In early summer, after our spring crops are finished (it gets too hot for most brassicas and other cool season crops), we plant a cover crop of sorghum-sudangrass, sunn hemp, sunflowers, and soybeans. The summer cover crop is where we grow the majority of our biomass. Our only other outside soil fertility input is soy bean meal for a little added nitrogen.

Being a two-person operation means we rely on tractor equipment to save labor. Tillage, bed preparation, mechanical cultivation, cover crop establishment, and termination are all done with the tractor.

Oklahoma is a challenging place for vegetable farming due to extreme weather. Spring storms are typically very strong with heavy rain and, not uncommonly, hail. Wind is also intense. This past spring, we lost over a dozen multi-hundred-year-old trees to either a small tornado or straight-line winds.

Although growing conditions are difficult, marketing isn't. We are able to sell over 90% of our produce directly to our customers at a weekly farmers' market in Tulsa and a 130-member CSA program (we wholesale the other 10% to a local co-op). We operate our CSA a little differently than most. Like traditional CSAs, members pay upfront in the winter. However, unlike most CSAs, they don't receive a box of weekly produce but instead come to the farmers' market to pick out their produce. It essentially works like a gift card. They take what they want when they want, and we subtract it from their balance. We find this model to be less work while simultaneously increasing traffic at our farmers' market stand. We have a CSA customer retention rate of over 90%.

Our main challenges are heavy rains on poorly drained soils and erratic weather (floods, droughts, extreme heat, late freezes, etc.). Although our sales have been consistent, we worry about demographic changes in our aging customer base. By and large, our customers tend to be over 50. We are exploring ways to reach a younger crowd and bring the next generation of dedicated farmers' market shoppers into the fold.

In 2016, Emily was appointed to serve as an Organic Producer Representative on the National Organic Standards Board (NOSB). The NOSB is a 15-member board appointed by the Secretary of Agriculture to provide recommendations for the USDA's National Organic Program. Members serve a 5-year term and consider and make recommendations on a wide variety of issues involving the production, handling, and processing of organic products. The NOSB meets in-person two times of year to vote on what materials and practices will be allowed in organic products.

As the organic market share continues to rise and ever larger businesses enter production, it is important that family-scale farmers are vocal in maintaining organic integrity. Small and medium-sized farms need to advocate for strengthening of the standards. The notion of "continuous improvement" is a cornerstone in organic production, but at stake is how that gets interpreted by the many different organic interests. Controversial topics like hydroponics and enforcement of the three-year transition rule are best served when farmers make their voices heard. For example, will paper chain transplant pots be allowed? The USDA is more likely to listen when farmers speak.

Family-scale farmers of under 180 acres still represent the overwhelming majority of all certified organic farms in the US (2016 NASS Survey Results). We are the face of organic. If we want standards that continue to reflect the values that brought us to organic farming, it's vital that we stand up in national debates.

Controlling Bird Damage with Raptors

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Natural predators can contribute to pest management, with associated economic and environmental benefits. In our research over the last several years we have investigated the effects of American kestrels, North America's smallest falcon, on pest birds in cherry orchards and blueberry fields. Here is what we have found, ways to employ this pest management tactic, and potential challenges.

American kestrels can be attracted to some fields with nest boxes. At the end of this hand-out are links to information about building and maintaining nest boxes. Kestrels nest in May and June and sometimes July. They are more likely to be helpful as a bird deterrent if your crop is ripening during those months.

Kestrels prey on insects, small mammals, and birds and we have good evidence that they deter pest birds in Michigan sweet cherry orchards (Shave et al. 2018). Occupancy rates of kestrel boxes can vary greatly from region to region. Eighty to 90% of nest boxes in northern Michigan sweet cherry orchards attract kestrels while in blueberry fields in western Michigan, occupancy rates are 30-35%. Western Michigan nest boxes also are often occupied by European starlings, an invasive pest species whose nests should be removed from boxes. So, the attractiveness of your location to kestrels will dictate how much management is required…if kestrels move in, a box simply needs to be cleaned out each fall and new bedding added. If your boxes are attractive to starlings, regularly removing their nests could be more of a headache than it's worth.

Boxes should be installed away from wooded areas to reduce the risk of occupancy by starlings. Open habitat (pasture or short-grass areas) with sparse trees/shrubs tend to be most attractive to kestrels. Boxes mounted on their own poles can be installed within a block, either at the end of a row or within a row in an open spot. Boxes should be installed at least one-half mile apart to allow for kestrel territoriality and 10 – 20 feet from the ground. Kestrel nests are more likely to produce young if boxes facing southeast. The bottom of nest boxes should be lined with wood shavings or animal bedding. Boxes that were occupied during the summer should have the wood shavings replaced during the fall or winter in preparation for the next breeding season.

If a starling occupies a box, it will add grass and other materials to the box and lay 5 – 7 pale blue eggs. A starling nest should be removed from the box, and new wood shavings added to the box if needed. Starlings are not native to North American and are not protected by the Migratory Bird Treaty Act so no permits are needed to remove their nests.

An important consideration is that kestrels eat voles and mice, so **rodenticides should not be used in fields when kestrels are present**.

With regard to economics, our research shows that consumers are enthusiastic about this type of bird management; informing your customers about your use of predator nest boxes may be valuable in marketing (Herrnstadt et al. 2016). Additionally, our economist colleagues at U.S.D.A., Dr. Stephanie Shwiff and Julie Elser, calculated the potential effects on the Michigan economy of widespread kestrel box installation in sweet cherry orchards. They estimated that, if all sweet cherry growers in the state installed kestrel boxes and had similar kestrel occupancy rates to those we measured, Michigan's GDP would be increased over $2 million and between 46 and 50 jobs would be created over a 5-year period. So, keep in mind that your bird management efforts reverberate to the regional economy.

As a final point, installation of nest boxes in agricultural production regions may aid in kestrel conservation efforts in North America; the species has been declining for several decades for unknown reasons. Please contribute to the nationwide kestrel nest box monitoring effort by registering your boxes with the American Kestrel Partnership: http://kestrel.peregrinefund.org/begin-obs

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Building, Installing and Monitoring American Kestrel Nest Boxes Plans for the "Spartan" kestrel nest box and mounting tower can be found here: http://www.nestboxbuilder.com/nestbox-article-spartan.html. Additional plans for kestrel nest boxes can be found here: 1) https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_063830.pdf

2) https://nestwatch.org/learn/all-about-birdhouses/birds/american-kestrel/.

Rats, Porcupine, Deer, and Squirrels… Oh My

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Mother nature is always "testing the farm's fences". Whether it is with insects, fungi, or animals – constant vigilance is important.

We have been growing 25 acres of PYO fruit at Butternut Farm for 15 years and in this presentation I intend to explain some of the more memorable wildlife encounters we have had, how we remedied them, and insights on those experiences.

Marauding herds of hungry deer, strawberry hungry Racoons and skunks, porcupines in our trees, cherry hungry birds, and most recently the squirrel apocalypse of 2018 will be discussed. I will have pictures of damage, the perpetrators, and how we solved some of these problems.

Growing Microgreens for the Specialty Market

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We have been growing microgreens since 2010. Our market channels include restaurants, food coops, and direct to consumers through farmer's market. This presentation will cover the process of how we grow micros, including varieties, seeding specs, cutting, washing and packing with an economical approach. We will introduce you to our electronic tracking for harvest and sales, which we started using this year, through the help of Smart Farm Innovations.

We have a dedicated small (18x24) greenhouse for micro production. We seed twice a week on a regular schedule from February through December. We concentrate on quick growing varieties so that our turn over is well-paced and greenhouse space is maximized. We make some exceptions for seasonal micros and always are working closely with chefs if they have a specific request.

We will cover all the equipment we use and the dos and don'ts of our experiences over the years.

Beautiful Profits: Growing and Marketing Edible Flowers

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My husband and I started this enterprise in 2018. We sell to catering operations, restaurants, and bakers, as well as retail at farmers' markets. Our main crops are nasturtium, pansy, marigold, strawberry, stock, and snapdragon. We have trialed hibiscus, with no success so far. We also sell 'flowers of opportunity', such as arugula and field pea from cover crops, as well as herb flowers.

We have tried different start dates with all of the flowers, with pansies, stock, and snapdragons in mid-January, which gave us nice starts to plant outside at the end of May, with them putting off flowers in the greenhouse in April, letting us get some early sales in. Nasturtiums started March 1st got extremely large, but took off when planted outside, with two subsequent bi-weekly seedings causing a slightly later flower date, but having very little effect overall on the production or lifespan of the plant. Marigolds and strawberries were started in March. Hibiscus was seeded early January through March 1st, every three weeks. Very few survived, and none made flowers before first frost. We are trialing starting a few in June and overwintering them indoors for a spring planting, although that start date might be later from now on, as they will be huge by spring. All flowers were planted out by the end of May, with hibiscus, strawberries, and snapdragons being the only plants not producing in the greenhouse.

Our first year, we put our flowers in a high tunnel, on a raised bed with biodegradable black plastic. This let us harvest regardless of rain, which can damage the blossoms slightly. The next year, we were entirely field planted, still on black plastic. We had to harvest strategically, but had very few issues with rain damage. We did all plants except nasturtiums and hibiscus at 3 row/30" bed, at 8" apart. Nasturtiums were planted at 1 row/12", which we will be extending to 18". Hibiscus should be planted 3 feet apart.

As far as diseases and pests, nasturtium flowers are attacked by flea beetles and earwigs. Ants will also often be in the blossoms, and need to be shaken out during harvest. Pansies get a minor rust-like leaf disease that we have not identified, and are attacked by deer. Nothing has attacked any of our other flowers so far. In the heat of summer, extended periods of time with the temperature being over 85 will slow or stop the production of nasturtiums, pansies, and stock. Pansies can withstand a mild frost, all others will likely die with the first frost.

The best-selling flowers differed depending on the market. Caterers will use almost anything, preferring small pansies and nasturtiums to decorate food, nasturtiums to stuff with goat cheese, as well as other small flowers for decoration, such as in ice cubes for drinks. Bakers and restaurants prefer small to medium pansies, and are more selective on color. At farmers' markets, we use 8oz compostable clamshells, and 4oz compostable cups. Nasturtiums and medium pansy clamshells are the most popular, as well as a mixed flower clamshell. We also use the clamshells to send small orders to restaurants, and a container that gets returned to us for larger orders. An 8oz clamshell holds 100 pansies or around 20 nasturtiums.

For wholesale, arugula flowers are 5 cents each, marigolds are 6 cents, small pansies, snapdragons, and stock are 7 cents, medium pansies are 8 cents, and nasturtiums are 9 cents, large pansies are 10 cents. Retail at markets, clamshells and cups of flowers are all $2 in which we put around 20 of each flower which gives us around 10 cents a flower.

We can typically harvest 100 flowers in 5 minutes, giving us the chance to make approximately $80-100 an hour. The seeds can be expensive depending where they are from; we found a nice selection from Ball Seed, though they tend to only have large quantities for sale. We also bought from Johnny's, High Mowing, and Harris. We chose specific varieties for color and size, based on what our customers wanted. Every growers needs will be different, and there is almost an unending list of varieties out there.

We use the following varieties for our flowers:

Nasturtiums: Alaska; Jewel; Tall Climbing; Orchid Cream; Night and Day; and Whirlybird.

Small Pansies: Sorbet mix; Penny mix; and Tiger Eye

Medium Pansies: Wonderfall Series; Frizzle Sizzle mix; and Yellow Redwing

Large Pansies: Mammoth Mix; Majestic Giants; and Spring Matrix

Stock: Harmony; and Hotcakes. (Note: All are supposed to be doubles, but if the plants get stressed, the will revert to being single flowers.)

Snapdragon: Antiquity mix; Twinny mix; Montego mix; Rocket mix; and Tetra Ruffled

Marigolds: Gem series; Durango Outback mix

Strawberry: Summer Breeze

Hibiscus: Red Drop

Production of Diverse Salad Mixes Using Mechanization on Large Acerage

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Over the course of a spring to fall growing season we grow cut greens on approximately 5 acres of silt-loam river bottom soil. We utilize tractor drawn implements, walk behind greens harvester, and a reefer truck to complete greens harvest in the field prior to storage in coolers. Salad greens are seeded and harvested on a weekly basis from May to October. We have narrowed our seeding mix down to 4 mesclun varieties, arugula, baby kale, and baby spinach.

The key to a successful salad mix crop starts with the right soil prep. We cover crop the previous fall with a winter rye cover, skim plowed and disced in the spring when ground is ready to work. Half to one acre blocks are then broadcast fertilized with composted chicken fertilizer at around 100 lbs per acre worked in with a Perfecta harrow and left to mellow for up to a week. Depending on the time of year, any weed flush after the Perfecta is knocked back with a tine weeder or another round with the Perfecta at a shallow depth. Beds are then shaped with a bed shaper. As the summer progresses and soils warm up we may flame weed beds prior to seeding to knock back weeds.

Seeding for all greens are done on a weekly basis with a Sutton Ag Jr. Seeder. We seed 17 lines within 42 inches on a 50 inch bed top. All mesclun and arugula crops are immediately covered with a 19 weight remay. Spinach and herb crops are left uncovered. If no rain is in the immediate forecast, the seeded beds are irrigated with a traveling water reel. This is especially important for successful spinach germination.

Harvesting is done with a walk behind, gas powered, greens harvester. This is a band saw blade type harvester that cuts a full bed width of greens which are then conveyed to crates sitting on a platform in front of the driver. One person cuts and collects the greens, while another person collects the crates of greens and takes them to the Reefer truck nearby. The Reefer truck temperature is kept around 50 F. Greens are then transported to the wash pack facility and stored in a walk-in cooler at 35 F until pulled for washing, spinning and packaging.

We utilize a greens washer made by China Joy that incorporates a stainless steel tank with a bubbler system and overhead water spray along with a conveyor to move the greens to a collection point. We collect the greens into a 40 gallon size plastic food-grade barrel that sits into our greens spinner. We can spin 10 to 20 pound batches at one time and achieve adequate dryness. Wash and spin time averages 100 plus pounds of greens per hour with two people working the washline. More time is required if there are weeds in the greens that need to be picked prior to washing. Greens are then packed out for sale in bulk bags or retail containers, or stored in clean plastic vented harvest bins for later sale if not needed for immediate orders.

App mash-up: MyIPM, Eco Apple App, Malusim, and netreefruit.org

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Although there are many handy apps out there you likely use in your orchard, I want to highlight four apps that I or UMass faculty and staff (among others) have been involved in development and/or testing and maintenance of the apps. They are MyIPM, Eco Apple App, Malusim, and netreefruit.org.

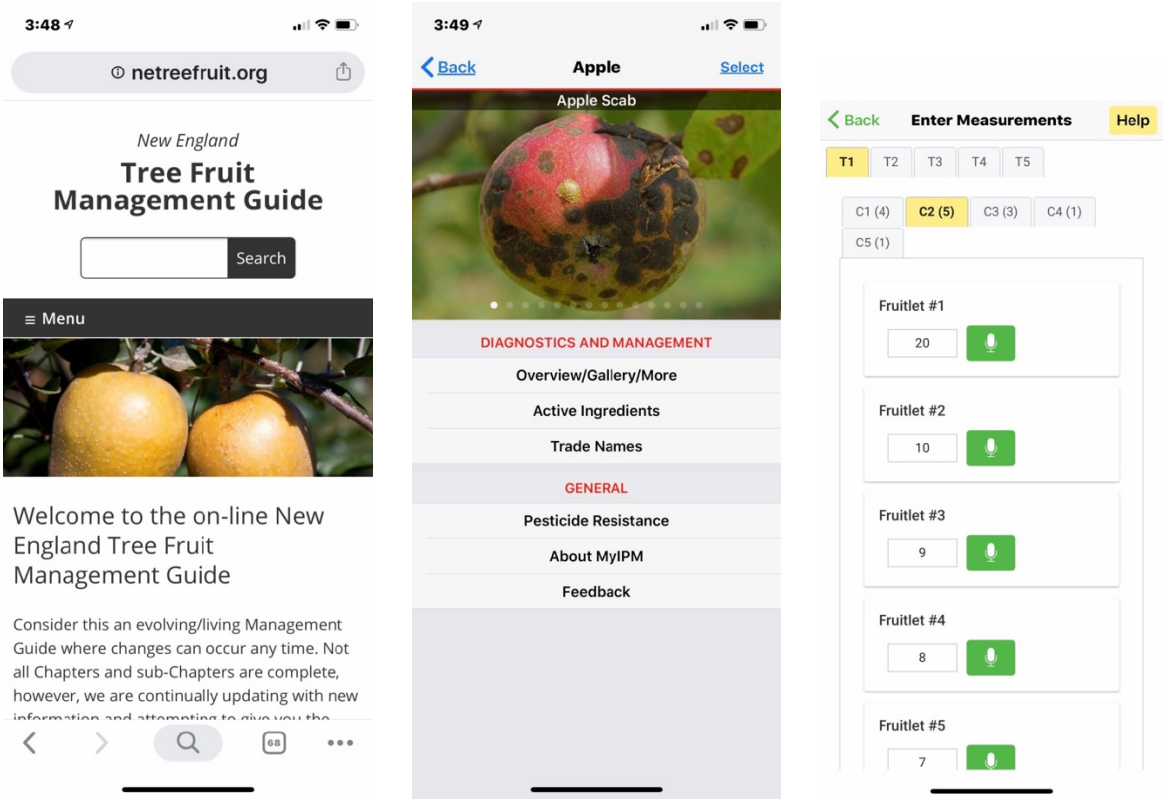
MyIPM – MyIPM is a collaboration of plant pathologists and entomologists of multiple fruit crops in the East to develop a handy tool to help with resistance management of fungicides and insecticides. For tree fruit growers, included in MyIPM are apple, peach, pear, and cherry diseases and insects. (There are also strawberry and blueberry.) Once the crop and diseases or insects of interest are selected in MyIPM, a menu with information on Diagnostics and Management and Pesticide Resistance appears. Sub-menus include Overview/Gallery/More, Active Ingredients, and Trade Names. To help with ID, a gallery of pictures of the particular malady are included, and just for fun, an audio transcript from a noted pathologist or entomologist can be heard. But the Active Ingredients and Trade Names of crop protectants for the particular disease or insect chosen are particularly helpful for resistance management, as the active ingredients are color-coded based on FRAC (fungicides) or IRAC (insecticides) Resistance Action Committee numbers. The numerical FRAC/IRAC code is also included, as well as Trade Name efficacy, rate, PHI, REI, maximum number of sprays and amount of product allowed per year. Trade Names also include information from the Pesticide Risk Tool (https://pesticiderisk.org/) which estimates the negative impacts of pesticide application. A bit more information including download links (Apple App Store and Google Android Play Store) here: https://apps.bugwood.org/apps/myipmseries/. MyIPM is updated annually and ongoing during the season.

Eco Apple App – the Eco Apple App is designed for growers using the Eco Apple® protocol to quickly access allowed pesticide information based on apple growth stages (phenology). It is a collaboration of Red Tomato, IPM Institute of North America, and UMass. To use the App, start by selecting the apple Bud Stage, then Pests of interest. You will be presented on-screen with a list of approved Eco Apple crop protectants that have been through a rigorous vetting process and present minimal risk to the environment and humans (applicators, workers, and consumers). Once the pesticide is selected, information displayed includes Type, Rate per Acre, Active Ingredient(s), Eco Restricted (no or yes with Restriction Details), EPA reg. #, REI, PHI, Signal Word, RAC number, and Manufacturer. The Eco Apple App is a quick reference for Eco Apple

growers in the field for information on approved products and is updated annually. But it is also handy for anyone growing apples and choosing to use pesticides with minimal impact on human health and the environment while still providing effective pest control options. Search for Eco Apple App on the Apple App Store or Google Android Play Store.

Malusim – is an advanced app that includes the Fruit Growth Rate Model, Irrigation Model, and Carboydrate Thinning Model. After initial location/block(s) set-up, including a NEWA station location (recommended but not necessary for all the models), the Malusim App can be used to enter fruit growth rate measurements (using either a keyboard or voice input) and predicting apple fruit set during the chemical thinning season. Predicted fruit set via the Fruit Growth Rate Model is immediately charted on-screen displaying either the number of fruit setting or percent fruit setting based on a specified target number of fruit. The Carbohydrate Thinning Model is charted (and tabular displayed) based on data from the selected NEWA weather station which is helpful in determining chemical thinning timing and adjusting rates. I am not as familiar with the Irrigation Model, however, in a nutshell it charts Daily and Cumulative Water Balance, Orchard ET, and Rainfall on a location basis (based on input from the selected NEWA weather station). Irrigation Records can be entered to adjust these values. The Malusim app is still under development and admittedly has some bugs, be sure to export your data frequently! Malusim was primarily developed by Cornell University post-doc's Poliana Francescatto and Jaume Lourdan and funded by the New York Farm Viability Institute and it is available on the Apple App Store or Google Android Play Store (search for Malusim).

Netreefruit.org – is a web app, because it needs connectivity to a web server, typically not a problem in this day and age of cellular data. (It is not downloaded from one of the app stores.) Netreefruit.org can be viewed using a web browser on your phone (or tablet or computer) at http://netreefruit.org and is the home of the New England Tree Fruit Management Guide. Every orchardist in New England should be using it now for current pest and crop management information on apples, pears, peaches, plums, apricots, and cherries. In addition to pesticide information -- timing, efficacy, rates, safety, pests controlled, etc. -- weeds, wildlife, nutrients, sprayer calibration, organic, and crop insurance information are available and updated annually. It is a living "document" so in addition to annually, changes to recommendations, etc. can be made anytime on-the-fly by collaborating tree fruit specialists in all six New England states. Design of netreefruit.org is "responsive" such that it is user-friendly whether using small mobile phone screen (although they are getting bigger!) or bigger tablet or computer screen. Be sure to bookmark netreefruit.org on your phone, tablet, and computer for quick reference to all your New England orchard management questions and recommendations.



iPhone screenshots from netreefruit.org, MyIPM, and Malusim apps respectively

Orchard Platforms

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At Wafler Orchards we use the Huron Fruit System Picking Platform. Designed by Paul Wafler, this machine was designed with picker ease and orchard efficiency in mind. The platform has elevated areas where up to 6 pickers can work and pick from. Five bins are held in the middle of the platform and five on the back trailer. This allows pickers to continue to pick through the unload of full bins and reload of five empties. The system works best with a bin trailer designed to feed the bins onto the platform trailer.

In the orchard we use these platforms for every task in our established orchards. Starting with dormant pruning, we run the harvesters during the winter, and in snow. We then use them for stringing wire in our new plantings, hand thinning, summer pruning, and harvesting. During harvest the platforms work extremely well for spot picking. The faster the platform moves the redder, larger apples will be picked because the picker does not have time to dwell on which apple to pick. We can travel rows with varieties such as gala and honeycrisp four times a year to pick fruit exactly when it needs to be picked, while still maintaining cost efficiency.

An additional component of the harvesters that is now being used is the Apple Pi software. This is a computer-based system that allows the machine to track information every time it is turned on. Information that can be collected is weather, distance, speed, employees clocked in, clock out time, and rows traveled in. Using our Apple Pi tablets, managers can tap into any machine and look at the same information the machine is collecting, as well as, grade the individual workers on performance and do a quality control check on the fruit.

Drape Net
Cost Effective Crop Protection

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Hail. As apple growers, we hate to hear about it let alone see it on our own farms. No one wants to hear that four-letter word come out of anyone's mouth, whether it be a meteorologist or our farm manager's. But the sad reality is that hail is becoming an ever more prevalent part of our normalized weather patterns. Whether you believe in Global Warming or not, we can all admit that the weather in the Northeast is changing. We seem to have higher highs, and lower lows, with a mix of events that would happen every ten years, seemingly occurring with much more frequency. With that being said, we here at Drape Net feel that we have a product that can help to mitigate the now ever more present risk of hail along with some additional side benefits that will pleasantly surprise all those who have seen and/or used Drape Net.

Drape Net is a cost-effective crop protection system. It was developed over 15 years ago in Australia by Michael Cunial. In Australia, there are regular hail storms that will rain down hail stones the size of golf balls. Michael realized that he couldn't keep on farming this way, where year after year his crop was either destroyed, or he was losing a lot more sleep than he would like to watching the weather forecasts and crossing his fingers that the next storm would miss his farm. He first looked into structured netting and couldn't quite come to terms with the price per acre. He couldn't understand why no one was offering a simpler option. Something where the growth of the trees could hold up the netting which would remove the need for additional structure. After much research into weave styles and patterns, Drape Net and the Net Wizz applicator were born.

Drape Net is a cost-effective crop protection system with so many benefits, one of which is excellent spray penetration while still giving your fruit coverage from hail. The weave of Drape Net has been researched and designed over the years to allow for this excellent spray penetration. The netting will actually diffuse the spray when it first hits, swirl the spray underneath, and help to keep some of the spray from drifting too far away from the fruit on the opposite side of the netting. We do not recommend changing anything in regards to a spray program with Drape Net. There should be no need too. Spray penetration should be the same and coverage should be the same if not a touch better due to the swirling effect created by the netting.

Drape Net can be ordered in custom widths that range anywhere from 4 meters wide (approximately 12 ft.) to 12 meters wide (approximately 36 ft.). All rolls of Drape Net,

regardless of width, come in 100 meter (approximately 328 ft.) rolls. Depending upon row spacing, one container of Drape Net can effectively cover 20 acres of fruit.
Drape Net is offered in two different colors, black and white. White netting is recommended for the East Coast and any red skinned varieties. The shading factor of white netting is between 12% and 15%. With this level of shading there can be a delay in fruit maturity by five to seven days. There may also be a delay in color between five and seven days as well.

Black netting has a shading factor of 18% to 24% and is highly recommended on the west coast mainly as a sunburn protectant. Black netting is recommended for green skinned varieties such as Granny Smiths. Black Drape Net on Granny Smith's in Washington state helped to provide the block covered with two packs per bin more on the covered fruit due to the elimination of sunburn issues that were very prevalent the year before. There was also a half size bigger difference on fruit underneath Drape Net as well as less water used on the block due to better water retention by the trees covered with Drape Net.

Drape Net will also help to reduce insect and bird damage. At an organic grower in Colorado, they have fully covered their organic Honeycrisp. They are seeing practically zero damage from any insects to the fruit underneath the netting. The fruit that isn't covered has a minimum of 50% damage. This was a farm that had 50% pack outs due to codling moth damage on their entire crop in 2018. In the early stages of 2019 pack outs were at 85% with only 15% damage.

In New York state on multiple trials that are ongoing in regards to Codling Moths, have found a serious reduction in trap counts underneath netting. Michael Basedow of Cornell has been leading studies in Northeastern, New York and you can view his trial set ups and results at https://www.nnyagdev.org/index.php/2019/09/03/nnyadp-apple-research-use-hail-netting-to-exclude-pests/.

Drape Net also helps with the bird problems that come with higher dollar fruit. In New York we deal with a lot of crows. The crows do not want anything to do with Drape Net and leave the fruit underneath it alone. If there are uncovered rows next to Drape Net, those rows are picked to pieces. In Washington, apple growers and cherry growers deal with crows as well as starlings and a noticeable difference has been seen between rows with Drape Net and rows without Drape Net.

In regards to applying and removing Drape Net, a realistic target of 10 acres per day for application and 15 acres per day for removal are the standards. With a crew of five people Drape Net can be applied at the ten acre per day pace. You will need one tractor driver, two people to guide the net down off of the Net Wizz applicator, and two people to put zip ties in on each side every twenty to thirty feet. Application may be slower in the first year as you can customize the lengths of your rolls of Drape Net to accommodate rows that are longer than 100 meters. You can field sew rolls together in the field to achieve the lengths needed for that row. When removing Drape Net, you can roll as much as up to 250 meters back onto one spool. This makes

removal much quicker and the application in the upcoming year much quicker as your roll is all set at its custom length already.

Storage wise there are two options for Drape Net. You can store the rolls in the field. We can provide plastic end caps and a black UV treated shrink wrap to wrap the rolls in to protect them over the winter. The two worst things for Drape Net are careless tractor drivers and ultra violet rays. With that being said the second storage option for Drape Net is to wrap it in regular shrink wrap and store it inside for the winter months, if you have the room for it. Either way we recommend putting mouse bait out around where the net will be stored as a precautionary measure.

Lastly, the timing for applying and removing Drape Net can vary by farm. We recommend putting it on as soon as possible after petal fall and not removing it until you are ready to harvest the fruit that is covered. You can do your thinning sprays and all other sprays with Drape Net on. Due to the fine art that is chemical thinning some growers opt to not put Drape Net on until after they are done with chemical thinning. Most of our growers also thin underneath the netting. They will cut the zip ties securing Drape Net to the trees ahead of the thinning crew a few rows ahead and go back through once they are finished and zip tie the netting back down behind them.

Currently, Drape Net costs $3,500 per acre for the netting and the Net Wizz applicator is $17,500. It is a large investment but hypothetically if you bought Drape Net and you didn't have hail; you could still make your money back in within three years. If Honeycrisp are selling at $50 per box, that's 70 boxes of fruit additionally per acre to cover your cost. If you had 2% bird damage in a block that gets pecked apart every year, would you gain at least 70 boxes on that acre? That isn't taking into account the fruit that could be packed due to less insect damage and in places where sunburn is an issue, less sunburn, and most importantly if there's been a hail event, little to no hail damage.

Tools Used for Spray Calibration in Europe.

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Summary
In Europe, technical sprayer inspections became mandatory as of 2011 for all type of sprayers used in agriculture and horticulture (Europe Directive 2009/128). The goal of the inspection is to assist farmers and operators with better functioning sprayers to reach a better protection of the crop with less inputs (pesticides) and less risk for pollution of the environment. AAMS has been created in 2002 to develop, build and market tools for inspection and calibration of sprayers in use. Testing tools start with the basis, validation of precision of pressure gauges used, checking flow and pressure capacity of pumps, pressure drops in the spray lines, flow rate (wear) of nozzles and liquid distribution in a vertical plane. The tools are being globally used world-wide and guarantee precise and correct measurements with the possibility to execute a high number of calibrations a day. These professional tools allow to adjust sprayers to the actual crop settings in a visual way. The calibrations performed with it can as such be better understood and used during extension actions to help growers to optimise their sprayer for changing conditions.

Introduction
Several European farmer organisations and their extension services understood in the early 80's parallelly that crop protection was getting more and more important to grow. This way they could grow healthy crops and to allow farmers to optimise yield and financial return (Germany, The Netherlands, Belgium and a few others). They also noticed that not all sprayers in use were meeting up to the needed quality to even spread the pesticides to reach this goal. In a starting phase, they started to organise specific training sessions for contractors to help them with pesticide application techniques. After some minor success, these actions were extended towards farmers and larger growers. Multiple questions during these theoretical courses, led towards some practical training sessions of calibrations (late 80's). The status of the sprayers presented by course participants was terrible (in all countries results and actions were comparable). 4 out of 5 sprayers had at least 1 defect that caused non homogenous spraying. Faulty pressure gauges and worn nozzles appeared on more than 50% of checked sprayers. These results didn't improve over the years, so other actions were needed to improve the status and functionality of the sprayers in use. Especially keeping in mind that those who brought their sprayer to calibration sessions/voluntary inspections were already the most motivated growers. This line can be drawn here as well, that also this paper will only be read by motivated growers that want to improve and progress. Local governments started a mandatory system of technical inspections of all sprayers in use in a way to improve the existing machine park to get better crop protection effects (mid 90's). Besides these inspections, new standardisation groups were started to also improve new sprayers, as the voluntary initiatives had shown severe shortcomings in a high number of new sprayers brought on to the market. As these local initiatives led to positive

overall results, the European Commission decided to make the technical inspection of sprayers mandatory for all sprayers used to spread pesticides by a European Directive (2009/128).

Why are calibrations/inspections a WIN-WIN-WIN-WIN-WIN situation?

What are the advantages for growers?

Growers will get a better functioning sprayer leading into better application results of crop protection agents, which will lead to higher yields and less losses. When sprayers are optimised and pesticides are more evenly spread over the target crop, growers can reach results as good as before with a lower amount of chemicals, which will result in a considerable reduction of inputs and cost saving. The risk of creating resistance against pests of all kinds will be less which keeps products available in the longer period.
Besides that, the risk of contamination of the operator will be reduced as well since sprayers are better adjusted and cleaned, while working in such way that all of the spray (liquid is directed towards the targets.

What are the advantages for the environment?

The environment will be less polluted when pesticides are more evenly spread (less risk of high concentration at some spots during applications). The spill (overapplication) of pesticides will be reduced, a lower concentration/amount will be required to get the minimal active dose all over the crop. This will lead to a safer and cleaner environment what in itself creates less resistance towards applied products.

What are the advantages for the food?

When less inputs (PPP's) are used and are more equally spread, the risk of finding too high residues is much lower. Spots with overconcentration will be lowered and less pests will remain on the crop and in the field. Food will become safer due to lower residues.

What are the advantages for the pesticide/chemical industry?

Since pesticides are spread better, chemical companies get less claims for non-working products and even less drift claims. They will have a higher efficiency of their developed products, making it less problematic getting new products approved and keeping existing products available for growers, as less residues are found on crops, the environment and drinking water. In Europe, all pesticide producing companies support calibration courses and inspection sessions, all to improve the way pesticides are used and brought in to their crop and the rest of the environment.

What are the advantages for the mechanical industry?

Growers will realise that not all existing sprayers can be adapted to the crops they actually want and need to protect. This will result in sales of more sprayers. The calibrations show and indicate faster when nozzles, pressure gauges or other parts need to be changed resulting in higher sales of spare parts, while on the other hand, less claims of bad functioning sprayers are found. Growers and/or operators participating in calibration sessions will be more motivated and interested in good quality sprayers.

Thus in the end, all concerned parties in crop protection have major benefits in good working and adapted sprayers. A good functioning sprayer, operated in a good manner, will result in greater yield, safer food and higher income and profit for the whole agricultural chain.

What products are used for sprayer calibrations and why?

Pressure gauge tester

When a grower wants to adjust a sprayer for dose, the first tool he must check in his settings, is the working pressure. Changing the pressure changes the flow rate and droplet size sprayed. New pressure gauges have typical precision classes of 1 and 2.5% of the final scale value, which means that they can deviate 1 to 2.5% of the highest value of the scale and still be within pressure gauge precision. In inspections and for optimal use of the sprayer, the pressure gauge should be adapted to the needs of the operator and a maximal error of 10% should be tolerated within the working range. A reference pressure gauge used for comparison should have a four times more accurate precision class in the tested pressure zone. We offer pressure gauge testers with and without reference pressure gauges in all different precision classes and with different end scale values. The test unit is build to be used in mobile service vans.

Nozzle pressure adapter

Once the pressure gauge is working correctly, the pressure can be set to have a correct output. To be able to rely on the read pressure, pressure losses should occur between location where pressure is measured and the location of the nozzles. These nozzle pressure adapters allow to check for pressure loss between working pressure gauge and nozzle position. When two or more adapters are mounted onto the sprayer, they allow to check if there are pressure differences between sections (e.g. blocked section filters), if no pressure loss appears within one section, if the pressure stability is within limits and if compensatory returns are functional or not.

Flow rate measurement

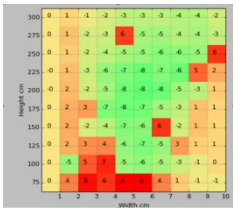
After checking all pressure settings, the actual output will be defined by the nozzle size. Nozzles wear depending on their design and material and even more pressure and the type of products been sprayed with it. Nozzles are seldom completely cleaned and too often used for a too long time. Worn nozzles will not only result in a higher output for the same pressure but also will start to spread liquid unevenly with other droplet sizes. Good functional nozzles are crucial for a good application. The nozzle flow rate measurement tools have universal adapter to collect the sprayed liquid that is guided towards calibrated measuring glasses. The result of such a measurement is visual and makes it easy to understand. This tool exists for multiple numbers of nozzles so that left and right side can be tested at the same time.

Vertical patternator

Once we have the flow rate correct, we still have to make sure that we get it at the right spot. The air/wind created to bring the liquid into the tree, needs to be adjusted so that the droplets are carried to the target we want to reach. As many growers have their own manner of planting and pruning trees, sprayers usually should be adjusted to each major plot. Even within a growing season, sprayers ideally should be adjusted to keep the amount and density of leaves into account. Therefore, a vertical patternator has been developed, that allows a quick measurement of the vertical liquid distribution. The straightforwardness of this tool with both visual assessment as an optional electronical reading unit allow a simple evaluation of the tested settings of fan, vane orientation and nozzle choice and orientation.

Airspeed profile

Most sprayers have limited capabilities for adapting the air flow over the full spray height. For new developments and for sprayers with multiple air deflector settings, the measurement of the air pattern (wind speed and wind direction) can help in getting the desired liquid distribution.



Pump capacity

The pump capacity has a less direct effect on the liquid distribution, unless the pump is not capable of supplying enough pressure and flow rate for correct spraying. More important is the extra capacity that a pump has for the hydraulic agitation. Many sprayed products require continuous agitation to have a constant concentration when spraying a full tank, especially powders and products as urea added to others require a more effective agitation. As pumps require regular maintenance, a quality check of the repair/maintenance of the pump is in general crucial.

Videos of the product can be found on our youtube channel:
https://www.youtube.com/channel/UCrTjdoVBecIzCzdSRLka5MA/videos

Re-tooling your Sprayer for Better Insect and Disease Management

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

Each season, farmers may apply spray materials worth $100-$500 an acre when using sprayers. Many of the materials applied can potentially protect the crops and plants from pests, provide 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. It is especially tricky to calibrate air blast sprayers properly.

Growers must frequently adjust sprayer outputs and vary application speeds throughout the growing season in order 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.

The precise application of pesticides is important. Problems with inadequate pesticide efficacy and phytotoxicity are often due to inaccurate sprayer 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 and 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.

Reasons for Calibrating

Chemicals should be applied at the proper rate to be effective and safe. The calibration test tells us the application rate for our selected nozzles, pressure, sprayer design and travel speed.

The operator must know the application rate. This is available on the chemical label and can determine the proper amount of chemicals to add to the sprayer tank. Once the actual application rate is known, it is easy to determine the acreage that a tankful can cover. The proper amount of chemicals to add to the tank can then be determined.

Chemicals must be applied at the correct rate. Too much is wasteful, may violate label rates, may cause phytotoxicity, and may pollute the environment. Too little will reduce the effectiveness, and money will have been wasted on the material and its application. Pest injury may also result. Many small fruit growers forget how a miscalibrated 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 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. Test 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.

The 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.

A vertical patternator is used to simulate the canopy of a crop that is more than two feet tall. It is placed at the end of the row, in-line with the crop. The sprayer is stationary. Turn on the sprayer and spray clean water out of the nozzles, with the fan turned on. As you test, select different nozzle configurations (number and orientation). Water is collected in the graduated cylinders. The results show the vertical distribution pattern.

Results from the patternator show great variability in spray patterns produced according to nozzle orientation and which side of the sprayer they are on. Remember, the rotation of the sprayer fan, can affect air and spray coverage.

Vertical spray patternators are used in Europe for inspecting and calibrating air blast sprayers. However, little information is available about their reliability, particularly when used for crop-specific calibration. Vertical spray patternators can aid in adjusting nozzle position and orientation if changes are made according to crop canopy size and geometry.

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

To test, 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 (on a pole, for example) in the interior, and low 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.

Bird Damage in Blueberries: Risk Factors and Management Strategies

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Risk factors for crop damage by birds

General Principle 1. When there is less fruit in a given area, there will be a higher proportion of damage to the crop that is available. One should expect higher proportions of damage in: 1) low-yield years, 2) early-ripening varieties, 3) small blocks.

General Principle 2. Blocks near resources important to fruit-eating birds are at higher risk. One should expect higher proportions of damage: 1) in blocks under wires, 2) at edges of blocks, particularly edges near non-crop areas, 3) near night roosting sites, 4) in isolated blocks with little human activity, 5) in blocks near dairy farms.

Each farm is unique and should be assessed for risk factors. For example, wooded edges of blocks can provide "staging areas" for fruit-eating species like American robins. The birds enter the blocks from the woods, eat, and then return to the woods. If a low-yield year is anticipated, or if your farm has some of these risk factors, it is recommended that you prepare bird management strategies early in the year.

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Bird management strategies

Bird management strategies can be grouped into several categories: 1) scaring, 2) barriers, 3) cultural management practices, for example encouraging natural predators, 4) deterrent sprays 5) lethal control and 6) more recently, interfering with birds' perception of their environments.

Scaring strategies. Birds habituate quickly to sounds and visual devices that are supposed to scare them. Simply placing decoys of predators or scare-eye balloons is not likely to deter birds for long. If one employs scaring devices, they should be deployed early in the season. Also, they are more likely to deter birds if there is some random component to their movement or sound. For example, inflatable tubemen should be moved within or around a block and, ideally, go on and off randomly. Propane cannons and devices that play recordings of distress calls or predator calls can be programmed to go on and off randomly. Some scaring strategies, like lasers, work in particular situations. For example, lasers deter Canada geese in low-light situations. Effigies (dead birds hung in the crop) may deter crows.

Preliminary studies of "laser scarecrows", where a laser beam sweeps over a field, show some promise in reducing bird activity in sweet corn. In recent preliminary work with drones in sweet cherry orchards, results were inconsistent but suggest drones may deter birds in some contexts. On some days, in some orchards, fruit-eating bird numbers were lower when drones were flying over a block. Larger-scale trials to investigate this strategy are warranted.

Barriers. Some growers use netting to deter birds; it was considered the most effective bird deterrent in a survey of 1500 fruit-growers (Anderson et al. 2013). Netting requires considerable effort and materials. If one employs netting, it is important that the netting enclose the vulnerable crop completely. Birds will easily get under the netting if there is a gap left between the bottom of the netting and the ground. Also, ideally, the netting will be on a frame to maintain some distance between the fruit and the netting. If the netting lies on the fruit, birds will simply reach through the netting to eat.

Increasing resources for predators of birds. American kestrels, small falcons, can be attracted to some fields with nest boxes. Kestrels prey on insects, small mammals, and birds and we have good evidence that they deter pest birds in Michigan sweet cherry orchards (Shave et al. 2018). Occupancy rates of kestrel boxes can vary greatly from region to region. Eighty to 90% of nest boxes in northern Michigan sweet cherry orchards attract kestrels while in blueberry fields in western Michigan, occupancy rates are 30-35%. Western Michigan nest boxes also are often occupied by starlings, an invasive pest species whose nests can be removed because they are not protected by the Migratory Bird Treaty Act. Areas with plentiful pasture or short-grass areas tend to be more attractive to kestrels. At the end of this hand-out is information about building and maintaining nest boxes and the best locations. An important consideration is that kestrels eat voles and mice, so rodenticides should not be used in fields when kestrels are present. Kestrels nest in May and June and sometimes July. They are more likely to be helpful as a bird deterrent if your berries are ripening during those months. As a final point, our research shows that consumers are enthusiastic about this type of bird management; informing your customers about your use of predator nest boxes may be valuable in marketing (Herrnstadt et al. 2016).

Chemicals. Bird deterrent sprays (there are several on the market) contain methyl anthranilate, a chemical allowed for use on fruits and vegetables. Methyl anthranilate is also a food additive that imparts a fruity odor to products. The method of action of methyl anthranilate is that it irritates nerves in birds' bills. Tests of the efficacy of methyl anthranilate products have not produced strong evidence that it deters birds in field situations. If you use sprays containing methyl anthranilate, apply them following the label as closely as possible to increase the likelihood of effectiveness. For example, bird deterrence may be improved if they are applied with foggers, which produce smaller droplets, than typical sprayers. Also, the sprays need to be reapplied after it rains.

Lethal control. Lethal control doesn't have a strong track record for reducing bird damage although it may be warranted in specific situations. Whether or not one needs a permit to kill pest birds depends on the bird species and the context. Please check your state's website about permitting requirements.

Interfering with birds' perception of their environments. Recently developed devices in bird management impair birds' abilities to perceive their environment and may have applicability in fruit-production systems. "Sonic nets", for example, are not actually physical nets; they are systems that broadcast noise at the same frequencies at which birds communicate, potentially interfering with birds' ability to warn each other about danger. One test showed that the nets

deterred birds from an airfield. By reducing birds' abilities to communicate and perceive predators, these techniques may be less susceptible to habituation than scare techniques.

Take-home messages
Assess risk
Decrease resources for fruit and vegetable-eating birds
Use a combination of bird management strategies

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Building, Installing and Monitoring American Kestrel Nest Boxes* Plans for the "Spartan" kestrel nest box and mounting tower can be found here: http://www.nestboxbuilder.com/nestbox-article-spartan.html. Additional plans for kestrel nest boxes can be found here: 1) https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_063830.pdf

2) https://nestwatch.org/learn/all-about-birdhouses/birds/american-kestrel/. Boxes should be installed away from wooded areas to reduce the risk of occupancy by European starlings. Open habitat with sparse trees/shrubs is desirable. Boxes mounted on their own poles can be installed within the block, either at the end of a row or within a row in an open spot. Boxes should be installed at least one-half mile apart to allow for kestrel territoriality and 10 – 20 feet from the ground. Kestrel nests are more likely to produce young if boxes facing southeast. The bottom of nest boxes should be lined with wood shavings or animal bedding. Boxes that were occupied during the summer should have the wood shavings replaced during the fall or winter in preparation for the next breeding season. If a European starling occupies a box, it will add grass and other materials to the box and lay 5 – 7 pale blue eggs. A starling nest should be removed from the box, and new wood shavings added to the box if needed. Starlings are not native to North American so no permits are needed to remove their nests. Please contribute to the nationwide kestrel nest box monitoring effort by registering your boxes with the American Kestrel Partnership: http://kestrel.peregrinefund.org/begin-obs

Heat Stress in Broccoli

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Broccoli is a very popular vegetable, an essential part of any outlet's vegetable assortment. Broccoli first found a place on the American table through a Boston produce distributor a century ago. Where did they decide to produce their broccoli? California. They went to great lengths to find a climate that would produce quality broccoli reliably, and Massachusetts was not it. Strangely enough, California is cooler than southern New England in one key regard: nights during the growing season.

California remains the place to raise broccoli, with the cool Pacific Ocean providing cool nights throughout the summer. In the 1980's an enterprising farm in the very north of Maine found that the nights there are cool enough to raise broccoli, and they have been expanding ever since. But summer heat has been a limitation in the rest of the East.

The Eastern Broccoli Project was established in 2009 with the goal of making broccoli a viable crop for eastern growers. One critical need was availability of varieties adapted to our climate. No seed company had been selecting for this environment, so that adaptation did not yet exist.

Heat stress as broccoli experiences it is not so much that the temperatures are too high, rather that the temperature is not cool long enough. Temperature is an environmental cue that broccoli uses to determine when it is the right time to flower. But that cue is designed to work well for flowering in the Sicilian winter, not the New England summer. The species *Brassica oleracea* is nothing if not adaptable. We should be able to produce a combination of genes that makes the heads and flower buds to develop normally even if the nights are a little warmer.

Increasing broccoli's adaptation to warm night temperatures has been possible in large part because Dr. Mark Farnham, with USDA-ARS identified this opportunity in the early 90's and was able to support an important breeding effort even though the payoff would be decades in the future. That future has arrived. Dr. Farnham's adapted hybrids, and others, are much better adapted to our climate. Some of these are on the market and many more are in the product-development pipeline with major seed companies.

The Eastern Broccoli Project has both public and private-sector breeders working on making high-quality broccoli that develops appropriately under our temperature conditions.

We have had collaborative work with Bejo, High Mowing, Seminis, Syngenta, Emerald, Takii, Known-You, Hazera, Harris Moran, Enza, Tokita, Tainong, East-West and Johnny's. They and others have much better germplasm that forms the basis of new and coming releases intended for the eastern US.

Heat injury symptoms:

- Uneven bead. Broccoli uses something comparable to chilling hours to determine when the flower buds should start to enlarge. If the accumulation is borderline, their enlargement is not coordinated. Some are oversize, some remain tiny or enlarge late. The result is uneven bead size, also called rough head or cateye.
- Leaf in head. When flower buds grow more slowly, a decline in apical dominance releases the leaf-like bracts in the head. These small leaves are usually tiny. When the growth energy of the plant goes into them, they can emerge from the top of the head.
- (Hollow stem)—fast growth when it expects to slow down. Warm growing conditions speed up vegetative growth. For the most part, that is helpful for getting a high yield in a shorter growing season. However, is stem growth does not slow down at heading, the stem easily widens faster than the center of the stem can keep up. The result is a hollow stem that is often deemed unmarketable.

There are also secondary properties that are important in the warm conditions:

- High dome on the head so rainwater shed easily. Warm water on the head allows rot to being.
- Disease resistance. Warm rain or fog encourages infection with *Alternaria*, downy mildew and other diseases.
- Holding ability. Warm growing temperatures make the head begin to loosen sooner, reducing the number of days heads are harvestable.

The Eastern Broccoli project is updating production recommendations to accommodate the challenges of summer production now that it is possible. We are also working to improve small and midsized growers' access to local markets that have generally been claimed by big distributors and grower-shippers.

Information about this project is available at easternbroccoli.org.

Updates from the Brassica Pest Collaborative:
Managing Cabbage Aphids, Flea Beetles, and Other Insect Pests

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The Brassica Pest Collaborative (BPC) is a project funded by Northeast-SARE that brings together Extension educators and researchers from UMass, UConn, UNH and Cornell Cooperative Extension of Suffolk County to collaborate on research and education to improve management of this suite of insect pests. Our educational efforts will help growers increase their knowledge of brassica pest biology and confidence to implement best management practices by 1) participating in web and phone based educational opportunities with experts from around the region and 2) attending field day demonstrations where key individuals will share their experiences implementing new and alternative control strategies. The proposed research will evaluate the efficacy of tactics like mulches, netting, and conservation biocontrol to combat multiple pests, reduce overall pest damage, and increase yield. Constraints like labor and time will be addressed by using cost to benefit analyses to help growers to identify new ways to increase profits growing brassicas. By coordinating research efforts, we are able to tackle a wide range of topics with a high degree of rigor, as treatments and protocols can be standardized and results can be considered together across site-years.

Our project goal is to work with brassica growers to adopt ecological pest control strategies including scouting, cultural practices, conservation biocontrol, and use of reduced-risk pesticides and that at least 50 growers are successful in reducing crop damage by 10% or more, increasing marketable yield and therefore revenue by $500,000.

The purpose of this presentation is to give updates on research efforts to date, and to share strategies growers are using now to improve insect pest control on their farms. Below are some preliminary findings and take-home messages:

"*Foliar Insecticides for Control of Cabbage Flea Beetles in Cabbage and Pak choy"*
by F. Zaman and D. Gilrein at Cornell Coop-Extension
Harvanta 50SL and Warrior II provided the best protection from flea beetles in both cabbage and pak choy. Assail provided intermediate efficacy and of the OMRI-listed materials tested, Entrust showed consistent reductions in flea beetle damage and increases in yield measures. Some of the OMRI-listed materials showed some efficacy on some dates but were not as effective as Entrust nor were they as consistent.

"*Beneficial Nematodes to Reduce Flea Beetle Population Size*"
by M. Meder, A. McStay, M. Ng, G. Higgins and S. Scheufele at UMass Extension

As tested, beneficial nematodes did not have any effect on flea beetle survival in the soil. This study was conducted in 2018 with no differences among treatments observed, and repeated in 2019 with more replication but still no differences were observed.

"*Using Mulches to Reduce Flea Beetle Damage and Improve Crop Yield"*

by M. Meder, A. McStay, M. Ng, G. Higgins and S. Scheufele at UMass Extension

In a 2018 experiment, reflective silver mulch significantly reduced flea beetle damage and plants were taller, more vigorous, and had significantly higher yields than plants grown in other mulches or in bare ground. This may be due to reduced plant stress from cooler soil temperature, or the reflected light may disorient or repel flea beetles, or it may be due to a combination of factors. The additional cost of the reflective silver mulch ($11/100 row ft compared to $3/100 row ft for black plastic) may be worth the investment, since a significant increase in plant growth and yield was observed. However, this study was repeated in 2019, once in spring using bok choy and again in the fall using both bok choy and broccoli. We found no effect of mulches on suppression of flea beetle damage to bok choy in either study. The bok choy was so attractive to flea beetles that no flea beetles were present in our broccoli experiment and no differences were observed there either. Since we have not been able to repeat the positive findings from our initial experiment, we cannot make a recommendation that growers plant broccoli using reflective silver mulch. However, if growers are interested in experimenting with using it on their own farms, we would recommend using it on a high-value transplanted crop like broccoli, but not preferred crops like mustard, bok choy, or arugula. Furthermore, we would be happy to assist growers with setting up an on-farm trial in 2020.

"*Evaluations of* Ammi majus *as an insectary plant for cabbage caterpillar conservation biocontrol*"

by Ana LeGrand at UConn Extension

Queen Anne's lace is known to attract many beneficial insects, including hover flies and wasps that parasitize pest species including caterpillars. This study examined the impact of growing Queen Anne's lace interplanted with cabbage on caterpillar parasitism. Preliminary analysis of the data showed that caterpillar number was reduced and parasitism was increased in one interplanted field but not another, indicating that field surroundings may play an important role.

"*Attracting Beneficial Insects to Reduce Cabbage Aphid Population Size and Damage*"

by M. Meder, A. McStay, M. Ng, G. Higgins and S. Scheufele at UMass Extension

and by A.Harris and B. Sideman at UNH Extension

and by Ana Legrand at UConn Extension

A regional survey for predators and parasitoids of cabbage aphids with three cooperating institutions developing shared protocols for observing and collecting beneficial insects in brassica fields. We are comparing 5-6 flower species for their relative attractiveness to syrphid flies and parasitic wasps. So far, we have identified >10 aphidophagous syrphids

collected from insectary flowers, and have determined that many are common across states. Preliminary data show that all flowers were hosts for aphidophagous syrphids and cilantro, alyssum, and Queen Anne's lace (*Ammi majus*) were more attractive to syrphids than dill, calendula, or purple tansy (*Phacelia tanacetifolia*) when all species were in flower. We collected a large number and diversity of wasps and were not able to identify all of them, but we did find the native aphid parasitoid *Diaretiellia rapae* in all flower species studied, and recovered them from aphid mummies in the experiment plots.

"*OMRI-approved insecticides to Reduce Cabbage Aphid Population Size and Damage*"

by M. Meder, G. Higgins and S. Scheufele at UMass Extension
and by A.Harris and B. Sideman at UNH Extension

Studies were conducted in 2017-18 to determine if OMRI-approved insecticides could be effective in reducing number and damage from cabbage aphids in Brussels sprouts. A UMass study compared 9 different OMRI-approved insecticides side by side and found, of the materials tested, M-Pede, Pyganic, and Azatin-O had the greatest reductions in cabbage aphid number, though the differences were not always significant. Another study conducted at UNH showed that Azaguard, Azera (azadiractin + pyrethrin), and Azera rotated with M-Pede significantly reduced aphid number or infestation of Brussels sprouts buds. Up to 91% reduction in infested buds was achieved by scouting regularly, spraying at the economic damage threshold, and using a rotation of M-Pede and Azera.

"C*abbage root maggot management strategies including exclusion netting"*

by F. Zaman and D. Gilrein at Cornell Coop-Extension

Conventional and OMRI-approved insecticides as well as 80 gram Tek-Knit netting were compared to the industry standard Lorsban. Verimark and Entrust SC applied as a tray drench with one follow-up application 15 days after planting were very effective, acheiving highly significant reduction in CRM damage. Verimark also provided season-long control of caterpillar pests. The best control was achieved with netting, which had no CRM damage and also no damage from caterpillars or flea beetles. Some challenges with using exclusion netting are controlling weeds and side-dressing under the nets. The research team used slow-release fertilizers and plastic mulch to address these issues with some success, and will continue to look at refining strategies for fertility and weed management under netting next season.

Flowers of Winter: Growing and Forcing Radicchio in the Northeast

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Varieties of Radicchio

All the varieties of chicory that we call radicchio originated in the Veneto region of northeastern part of Italy in the last hundred years or so. It is believed that Dutch horticulturalists working at Venetian villas began selecting local landrace red chicories around 1900, and taught local farmers how to force secondary growth indoors, as for witloof, aka Belgian endive.

Each of the main types of radicchio are named for the town in the Veneto where they originated. Chioggia is the round, red chicory most commonly seen. Treviso refers to the upright red type; either precoce (early) Treviso, which looks similar to a romaine, or tardivo (late), a loose head of curly leaves that has been forced indoors. Lusia radicchio has a variegated leaf and makes a round head that is not as tightly packed as chioggia. Castelfranco radicchio is actually a cross between escarole and chicory and makes a spiral, rose-shaped head with a creamy yellow leaf flecked with red. Verona radicchio looks like a cross between treviso and chioggia. A selection of Verona with a pink leaf, known as Rosa di Verona has become the internet's favorite vegetable in the past few years. It is the newest of the principal varieties to be developed.

Climate & soil considerations

Radicchio can be grown as a spring crop but it is more commonly grown as a fall crop because it is frost tolerant and can hold well in the field, and is suitable for short term storage. Veneto has a hot summer, long, mild fall, and a cold winter for Italy, but not compared to the northeast. Most types of radicchio are frost hardy down to around 25F.

Compared with the Veneto, New England also has a hot summer but a much shorter period of cool fall weather and thus a much shorter season for maturation and harvest of radicchio. Our primary harvest season goes from late September up to mid-November, but in the Veneto, harvest continues well into December and January. (Arguably, the Pacific Northwest has a superior climate for radicchio, boasting a cool summer, long fall, and mild winter. The combination of northern latitude, general gloom, and warmer winter temperatures actually allow radicchio to "force" itself in the field.)

For both spring and fall crops, bolting is a primary concern. Research and observation suggest that limiting available N during the initial (hot season) growth can greatly reduce the incidence of bolting. Growing a spring cover crop with a legume such as oat/pea prior to fall radicchio is preferable to incorporating granular fertilizer at planting. Tip burn can also be an issue in hot

weather. Providing adequate irrigation can help with both issues. A light side dressing of N in early September can help the plants head correctly in cold weather.

Seed & Seedlings

There are three basic choices when selecting radicchio seed: the cheap OP (open-pollinated) varieties, which are essentially unimproved land races; Dutch-bred F1 hybrids like Indigo & Fiero sold by Johnny's; and commercial OP seed from Veneto produced by T&T, which is available from Osborne Seeds. A word of advice: don't buy the cheap seed. The commercial hybrids perform well under standard high-input nutrient management systems and reliably produce crops in our short growing season. The Italian seed is very good but requires much more careful attention to soil, plant date, and climactic conditions. Many of the varieties available from T&T are for late season (December) harvest and not suitable for the northeast. Osborne carries many varieties in their catalog but will special order anything from T&T. It's expensive but worth it.

At Kitchen Garden Farm we grow radicchio seedlings in a standard 128 plug tray. Vacuum seeding raw seed is a pain and requires thinning between 7-10 days after seeding. Use pelleted seed if available.

Planting Dates for Fall

Fall radicchio is sown after the summer solstice until the Fourth of July, under shade cloth for germination, moving to full sun in the propagation house after 2 weeks. We do two large plantings, about 2 weeks apart. Radicchio takes 4 weeks from seed to transplant. Castelfranco and Lusia (bel Fiore) perform well when planted as late as August 7 in Massachusetts (zone 5). Leonardo planted August 1 will give you a nice crop for storage. Radicchio planted before July 20 will be at high risk of bolting, tipburn, and weeds.

We plant radicchio 3 rows to the bed, 15" between rows and 12" in the row with a Checchi & Magli carousel transplanter. I highly recommend one of those for anyone growing more than an acre of fall radicchio because the planting window is so short, and it invariably falls during a heat wave, causing lengthy delays. Weeding is done with basket weeder 3-7 days after planting and again around 2 weeks. Once plants are firmly rooted we use the finger weeder. For last cultivation we broadcast fertilizer and incorporate with shovels.

Harvest

Harvest of the fall crop usually starts around the end of September and peaks in late October. Demand for our radicchio remains strong for as long as we can hold onto it. We bulk harvest chioggia and early treviso before temperatures go below 20F, usually the first or second week in November. Heads of radicchio are harvested with some outer wrapping into bulb crates and then the pallets are wrapped and stored at around 36F in the cooler. They store well into January.

Putting row cover over radicchio when temps start dipping below 30 is a good idea and will prolong the harvest. At our farm the field is so large and mostly harvested by that time that we don't use row cover, but it might be worth it on a smaller scale, or if designated rows are left alone for late harvest.

Pricing

We wholesale our crop in half bushel (usually 12 count, 10lb) and 1 1/9 bushel (24 count, 20 lb) waxed boxes. Most of the time we field pack into wax. The half bushel is $25-$30 and the bushel is $40-$50. We sell forced tardivo for $12/lb.

Forcing

Around November 1st through Thanksgiving we harvest tardivo for forcing. We try to put a good amount to force every week until the middle of December. The plant is dug up root and all, some outer leaves stripped away, and placed in about 3" of water in a heated location for 3 weeks, ideally at 55F. Plastic tubs for mixing concrete are a good cheap option for forcing. Plants do not require total darkness. Good air circulation is much more important. Ideally the water would be constantly running or circulating.

After 2-3 weeks most of the original leaves will have withered and inside there is an incredible beautiful head of radicchio. The heads are carefully trimmed and the root whittled to a pleasing nub, then washed and packed for sale. Unforced plants can be stored for several weeks in the cooler prior to planting. The plants have to be in good condition when they enter storage or they won't keep more than a couple weeks before rotting. This year we are also experimenting with forcing pink (Rosalba) and castelfranco type radicchio. The season for forced radicchio is usually the last week of November through the middle of January.

To-do List for Researchers & Breeders in the Northeast

A lot of work still needs to be done to improve the agronomy of radicchio.

1. Breed Northeast adapted radicchio starting with commercial OPs from Italy and selecting them in a northeastern climate. Uprising Seed is doing this in the PNW and breeders need to do the same here as well.
2. Conduct scientific research into the fertility requirements for radicchio. There is a lot of talk on this subject between growers but it requires serious study and extensive trialing over many years to reach any conclusions.

Swede Midge Biology Basics and Management Updates

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Swede midge (*Contarinia nasturtii*) is a serious invasive pest that is currently causing up to 100% losses of broccoli, kale, Brussels sprouts, and other cruciferous (*Brassica*) vegetables in Vermont, New York, Québec, and Ontario. The midge, believed to be from Europe, was first detected in North America near Toronto in the 1990's (Hallett and Heal 2001). The midge has since spread to several U.S. states and Canadian provinces, as far east as Maine and Nova Scotia and as far west as Minnesota. Due to its small size (Fig. 1) and hidden larval feeding habits, this galling fly is often undetected until populations are difficult to manage on farms. Midge feeding causes scarring, deformation, and lack of head formation in crucifers (Hallett 2007; Fig. 2).

Several aspects of the midge biology and life cycle create challenges for managing this pest. First, swede midge is present on farms throughout the main growing season in North America, from first emergence in May/June until October/November (Hallett et al. 2007, Hallett, Goodfellow, et al. 2009). There are several overlapping generations in the Northeast, creating pest pressure throughout the season. Second, midge larvae are difficult to monitor and manage due to their small size and feeding habits. Adult midges lay eggs within the growing points of their host crops. Eggs hatch into larvae that feed on the newly forming leaves, protected from contact from non-systemic insecticides. By the time plants begin showing symptoms, larvae have dropped to the soil to pupate and insecticidal treatment is too late. Because no midges are present when symptoms appear, plant damage is often misdiagnosed as nutrient deficiency or environmental stress (Hallett and Heal 2001, Chen et al. 2011). Third, heading crucifers, particularly broccoli and cauliflower, are susceptible to economic damage by swede midge from seedling stage until early head formation, and only one feeding larva can cause a cauliflower head to be unmarketable (Stratton et al. 2018). Therefore, crops must be protected for the majority of their growing time. Lastly, the midge is challenging to manage due to its ability to overwinter as pupae in the soil for up to two or three years (Des Marteaux et al. 2015). In the fall, midge pupae remain in the soil in fields where cruciferous vegetable crops were grown, emerging there in the spring. However, a portion of the pupae will remain in the soil, emerging in the second and third year. Therefore, on small-scale vegetable farms growing crucifers using crop rotation, the entire farm may be infested with swede midge within a few years.

Small-scale, certified organic vegetable farms are the most at-risk for economic losses due to swede midge. Because the midges feed underneath newly forming leaves in the growing point, they are unaffected by most non-systemic insecticides. There are currently no OMRI-listed products that are consistently effective in managing swede midge. Spinosad, pyrethrins, azadirachtin, kaolin clay, essential oils, and other OMRI-listed products have shown little efficacy

in on-farm research trials (Seaman et al. 2014, Evans and Hallett 2016; pers. obs.). Using conventional management, neonicotinoids and other systemic materials are available, and must be used regularly in rotation until head formation (Hallett, Chen, et al. 2009, Chen and Shelton 2010, Chen et al. 2011). In areas of heavy infestation, many growers use calendar sprays of insecticides, reversing years of progress toward integrated pest management. Due to the hidden feeding and small size of the larvae, the usual "scout-and-spray" approach for other crucifer pests, such as caterpillars, is not effective for swede midge.

Because insecticides are not an option, physical and ecologically-based management strategies are necessary to control swede midge on organic farms. Currently, no biological control agents or resistant plant varieties are available for swede midge (Hallett 2007, Abram et al. 2012, Jones 2017). Spatially and temporally wide crop rotations away from infested ground can be effective to prevent yield loss, but can be difficult for small farms. Midges can be swept by wind and carried to nearby fields. It is suggested to rotate at least one mile away from fields that have had swede midge within the past two years. While fine mesh insect exclusion netting for crops is effective for swede midge, it is often cost prohibitive for most growers (Hodgdon et al. 2017). Additionally, netting is only effective when installed over ground that hasn't experienced swede midge infestation in at least two years.

With limited alternatives to insecticides, more research is needed to develop new strategies for swede midge management. Given that larvae are difficult to manage once inside the growing point, management tactics that target adults and prevent egg laying are particularly promising. Our research has shown that ground barriers, such as landscape fabric and plastic mulch, smother and prevent midges from emerging from the soil following pupation. Further work is needed to develop recommendations for using barriers, including timing of ground barrier installation and duration of cover.

Pheromone mating disruption (PMD) is another experimental tactic that has shown promising results for swede midge in both Europe and North America (Samietz et al. 2012, Hodgdon 2019). Mating disruption, a practice more common in orchards and vineyards, involves releasing unnaturally large quantities of synthetic female pest sex pheromones from emitters, which confuse males and prevent them from locating females (Welter et al. 2008). As a result, pest populations decline over time. However, one major challenge for swede midge PMD is the cost of pheromone synthesis. The swede midge pheromone consists of a blend of three compounds with structures that are complex and time consuming to synthesize (Hillbur et al. 2005). After four years of PMD research in Canada and the U.S., we have screened four pheromone blends and studied the reproductive behavior of the swede midge in order to improve the efficacy and economic viability of PMD for this pest. We found that the natural pheromone blend for swede midge is the most effective in providing crop protection, and in one year of our study, resulted in a ninefold increase in marketable broccoli yield compared to our untreated control (Hodgdon 2019). However, further research is necessary to explore ways to reduce the cost of PMD, including reducing pheromone inputs and improving emitter efficiency.

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Fig. 1. Adult swede midge, approximately 2 mm in length

Fig. 2. Distortion of growing point (left) and lack of head formation (right) in broccoli due to swede midge

Soil Moisture Monitoring on NH Fruit and Vegetable Farms

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Understanding the effects of rainfall and irrigation events on soil moisture provides critical insight for growers about the present growing environment for their crops. While experienced growers have learned over seasons of observations how their soils and water interact, utilizing a soil moisture measuring device of some sort enables them to put a number on their observations and more accurately track trends over time.

In 2018, UNH Extension began partnering with eight farms in Merrimack and Belknap counties to install soil moisture sensors in a variety of crops including a high- density apple planting, highbush blueberries, field-grown mixed greens, high tunnel tomatoes, field-grown peppers, and Christmas tree seedlings.

Monitoring soil moisture levels on these same farms continued during the 2019 production season, and growers reported that the information they gained as a result of monitoring was very beneficial. Some growers plan to purchase their own set of sensors and accompanying reader once our project concludes.

Grower Feedback

The information that has been gained from a grower's perspective throughout this project has been quite diverse. There were instances where irrigation cycles were occurring too often and for far longer periods than needed to achieve field capacity of the soil. There were also instances where the use of sensors revealed malfunctioning irrigation system components by reporting unusually dry soil in areas that should have received ample irrigation. The sensors have allowed growers to more accurately determine the frequency and duration of irrigation events needed, based on soil moisture trends, and maintain adequate moisture for the crops being grown. On many occasions, information from the sensors resulted in growers waiting an extra day or two to irrigate, avoiding unnecessary irrigation. The goal of this project is to provide growers with a useful tool and information resulting in a higher level of water use efficiency. Essentially, to use the water we have as efficiently and effectively as possible.

Sensor Types

The sensors we used fall into the category of GMS (Granular Matrix Sensors). This category of sensors provides a reading based on the electrical resistance between two electrodes embedded in the granular matrix within the sensor. The more soil moisture available in the soil, the lower the resistance and the corresponding number on the reader. This resistance reading is reported in kilopascals (kPa) or centibars. Both of these readings are equal as a resistance measurement. The specific sensors we are using in our fieldwork are WATERMARK model 200SS.

As an example, a reading of zero would tell us that we have a fully saturated soil, while a reading of fifteen would be somewhat drier. It helps to think about these numbers in the sense of how hard the plant has to work to pull water from the soil, defined as soil water tension.

Another traditional instrument used to measure soil water tension, the tensiometer, is designed to simulate a plant root and provides the same units of measurement as the WATERMARK sensors.

The WATERMARK sensors have been calibrated to provide readings based on the format of soil water tension, and thus the readings from both the tensiometer and WATERMARK sensors are easily comparable.

Think for a moment about the implications of how this data could be used by growers to help minimize plant stress or disease caused by excess moisture, or how important adequate moisture is for efficient nutrient uptake by the plants. You can begin to see how the readings provided by these sensors can be utilized to fine tune irrigation management strategies and to better manage the growing environment for specific crops.

Installation

Proper installation of the WATERMARK sensors can be accomplished in several ways. Here in New Hampshire, we've been closely following the manufacturer's instructions. Simplified, the standard sensors come with a two-wire lead measuring five feet long. This lead is threaded up through a section of PVC pipe of the desired length depending on your intended sensor depth in the field, glued in place with PVC glue, then capped with another section of larger diameter PVC with a cap and slid over the top to keep moisture out of the tube.

Before installing the sensor in the field, there is a recommended wetting and drying process that needs to be followed to ensure the sensors quickly responds to changing moisture conditions. Good soil contact with the sensors is essential to ensure accurate readings. Follow the manufacturer's instructions to ensure proper installation. Sensors can quickly and easily be moved from one location to another to better understand the dynamics of soil moisture in relation to soil types, irrigation cycles, topographical changes, etc., so long as the installation instructions are followed with each move.

Interpreting the Readings

To take readings using these sensors, growers need access to a digital data reader which simply connects with clips to the end of each wire lead. The cost of these readers was $210 at the time this publication was written. Each sensor costs $36, and a pair of two is recommended for each location. Having two sensors allows growers to better understand the effects of irrigation at varying depths within a planting or block. Sensor depth can be adjusted depending on the rooting depth of the crop.

Established recommendations for soil moisture in specific crops and soil types are available. These recommendations provide growers with additional information on which to base their

irrigation decisions. In most soils, other than heavy clay, the decision to irrigate would generally happen with sensor readings in the range of 20 to 40 kPa. Differences in soil type should be considered when determining the appropriate range for irrigation. This is because different soil types have varying levels of plant-available water at various soil moisture readings. To clarify, a soil moisture tension reading of 40 kPa in a sandy loam would mean that approximately 50 percent of the water in the soil is available to the plant. Comparatively, a loamy sand soil would have only 35 percent plant-available water at the same 40 kPa reading.

This reinforces the importance of knowing the soil type, along with monitoring soil moisture and visually observing crops and soil to make an informed irrigation decision. Additionally, the method of irrigation should also be considered. For example, it is recommended to begin overhead irrigation when the available soil moisture is no less that 50 percent, while drip irrigation, taking comparatively longer to distribute substantial volumes of water, could be started before the plant-available water drops below 80 percent. Using the sandy loam example from above, this would mean that a reading around 17 kPa would trigger a drip irrigation event.

USDA Northeast Climate Hub Funded Work

A special funding opportunity to support soil moisture monitoring work in New Hampshire became available in the spring of 2019. The USDA Northeast Climate Hub agreed to fund a project to install soil moisture sensors on existing weather stations maintained by UNH Cooperative Extension in partnership with farms across the state. These weather stations collect and feed data into the Network for Environment and Weather Applications (NEWA). To access station data, visit newa.cornell.edu and click on the station pages tab to find New Hampshire. There you can select the station nearest you for local information. The five stations currently collecting soil moisture data in New Hampshire are Boscawen, New London, Goffstown, Durham and North Haverhill. The addition of soil moisture sensors allows for farmers to access soil moisture data from farms in their region. These sensors are placed near existing weather stations in a variety of crops, and the information collected will allow growers to track soil moisture and become familiar with how to interpret the data to make irrigation decisions. Ultimately, there is no substitute to on-farm monitoring for the most accurate assessment of the current soil moisture situation on any individual farm. Use the data captured to better understand how to interpret soil moisture readings, but plan to start using moisture sensor technology yourself for best results.

UNH Cooperative Extension is grateful for the support of the USDA Northeast Climate Hub. The funding provided allowed for the materials, time and travel required to complete the project and publish this fact sheet.

Learn more about the USDA Climate Hub: https://www.climatehubs.usda.gov/hubs/northeast

How We Track Net Profit by Crop

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Tracking profit boils down to a lot of data collection. We grow a wide variety of vegetables, however, so tracking data on all crops can be a time-consuming task. To balance between data collection time and understanding profitability of our crops, we've selected the seven crops that we grow in large volume. Understanding the profitability of these select crops gives us the backbone of understanding the profitability of our vegetable operation as a whole. The practices we apply to these core crops we can then also apply to crops we grow in smaller volume with minimal effort.

Data collection starts with systems in place to make it efficient for crew to record the information we need to assess crop profitability. We stress during job training that data collection is an essential part of the job and we follow through with these expectations. Clipboards and paper data sheets are in each hoophouse to record data needed for hoophouse crops, and this data is later entered into google sheets. Field data is collected via phone or ipad into google sheets we have created. During wash sessions all harvest yield data is collected for every crop and can be traced back to particular plantings and seedings if needed. This harvest data is entered in googlesheets and crew members input data on an ipad as we work so there is not large amounts of data entry to happen later.

Other crop inputs we track through a crop task log in google sheets that includes items such as fertilizer types and application rates, any sprays used, etc…. Greenhouse transplant costs (that we grow) are also tracked, as are equipment and hoophouse use, allocated in portions to crops and depreciated over time.

We track the following data for each core crop:

- material inputs costs (plants, seeds, fertilizer, pest control, infrastructure/equipment use, heating fuel for hoophouses),
- labor costs (field and bed prep, transplanting or seeding, crop maintenance, harvest, wash/pack),
- total production, and
- total sales, allocating production to prices based on actual sales.

Note that we do not record every task every time we do it. We'll record several sessions of each task to establish labor rates for particular tasks (which can apply to numerous crops). These rates are helpful in doing quick crop profitability budgets for minor crops, without having to do extensive data collection. For our major crops we select a few crops each year to record all tasks and inputs and all yield in total for a whole season. This gives us a more detailed look at these important crops.

We use crop profitability worksheets developed by Richard Wiswall and NOFA-VT to plug in all our data for a particular crop. We export sales data from our accounting software (QuickBooks) to get crop pricing and sales volume at different price levels. All of our overhead costs data is also easily summarized in QuickBooks, as are our labor costs (including taxes, workers comp insurance costs, etc…).

It has been interesting to see where our costs can shift from year to year in a given crop if one step of production goes awry. For example, if our early weed control is not good in carrots and we end up with more hand weeding labor, profitability goes way down. So we may decide to abandon that crop and start over if it will cost less than trying to bring it back. Seems obvious, but when you see how the numbers really affect crop costs in particular areas of production it helps to make decisions on the fly from season to season about how to manage particular crops. It has also helped us decide to stop growing many crops that we just did not grow well or for which we could not get the pricing we needed in our given market. We still maintain a diversity of crops in smaller volumes for our CSA and farmstand sales, but doing crop profitability analysis has helped us decide where to focus in our wholesale program to balance customer needs with our skillset and infrastructure and equipment investments.

Pruning High Tunnel Cherry Tomatoes

Amy Ivy (retired) and Judson Reid, Cornell Cooperative Extension

Pruning & Training

Cherry tomatoes thrive in the protected conditions of a high tunnel and are less prone to cracking where water supply is controlled. Well trained tomatoes are easy to work around, have better air circulation, optimum light penetration, and higher yields as excess foliage is removed to focus plant energy on producing and ripening fruit. If left untrained, tomatoes will quickly form a tangled mess that is difficult to maneuver through and harvest.

There are many types and varieties of small-fruited tomatoes. In this publication we are focused on indeterminate 'cherry' tomatoes, as compared to the larger 'slicing' tomatoes.

Is it worth the labor cost to prune and train? Yes!

In response to growers' questions we conducted two seasons of research, comparing three pruning/training systems: an intensively pruned single leader, a double leader and a less intensive system (dubbed multi-leader) which started as a double leader and had no additional pruning once harvest began.

The double leader system proved to be optimal for yield and labor.

- The single leader used the least labor for pruning and harvesting but had the lowest yield (figures 1 and 4)

- The multi leader had an acceptable yield but took longer to harvest, reducing net profit

- The double leader was moderately efficient to harvest and had the largest yield and **largest net revenue** when labor was factored in.

Cherry tomato varieties have an indeterminate growth habit. This means they keep growing and bearing as long as temperature and light allow. They are essentially a vine and produce the most fruit when carefully pruned and trained vertically.

All tomatoes produce suckers above every leaf. Left unpruned, each sucker will grow into a shoot with leaves and fruit. If every sucker remains, all those shoots, leaves and fruit compete with each other for nutrition, light and water. In cherry tomatoes all these shoots become dense and tangled if left unpruned. By limiting the number of suckers and leaves, plant energy is directed to the remaining shoots for optimum yield and quality and labor efficiency. It is best to remove suckers while still small to direct plant energy upward.

Pruning to the 'Strong Y' (see figure 2)

1. Remove the leaves up to the first flower cluster (blue arrow).
2. Leave the sucker just under the first flower cluster (red arrow) and remove all suckers below that point.
3. The stem should now look like the letter 'Y' (yellow dotted line).

How Tomatoes Grow

Tip: Removing Lower Leaves (see figure 3)

As tomatoes grow taller their lower leaves no longer contribute to plant health. Removing the lower leaves, up to the lowest fruit cluster, allows for better air circulation for less disease pressure.

A handy method of removing leaves is to first bend the leaf upwards and then downwards. Listen for a soft 'snap' with each movement. If the leaves only bend and do not snap, use a sharp knife to cut them off close to the stem. Snapping is preferred to cutting so the leaf can separate at its natural point of attachment. Use caution to not tear off the leaves which may leave a ragged stump or tear that will be slow to heal over. A clean snap will seal off quickly, and will be easier in the morning when the plants are turgid.

Training and Pruning Indeterminate Cherry Tomatoes

Training - Provide vertical support

1. Decide on 1 or 2 leaders per plant. Our research found that 2 leaders was optimal in terms of labor and yield.
2. Set the plants at the proper spacing. For cherry tomatoes allow 12" in-row spacing between each leader. This means: 12" between single leader plants, 18" between double leader plants with 2 overhead wires to spread leaders perpendicular to the row;24" between double leader plants in a double staggered row pattern (best use of space).
3. Drop lines down from the overhead support, 1 line for each leader.
4. Use a tomato clip to fasten the line below the first leaves, add clips every 6-12" up the stem

Pruning

1. For a single leader, remove all suckers and all leaves below the first flower cluster. The result is one long vine-like leader with no side shoots. This method takes the least amount of time but has a lower yield.
2. For a double leader (recommended), establish **The Strong Y**. Each arm of the Y will become a leader, 2 leaders per plant.
3. Maintain the leaders throughout the entire growing season by continually pruning off all suckers that form. This will need to be done at least weekly, especially during the first 6 weeks.
4. Continue removing lower leaves as each fruit cluster is harvested. Remove leaves gradually, 1-2 each week, rather than too many at once.
5. If using a spool, lower the vines as the lowest fruit clusters are harvested. The vines will bend as they are lowered.

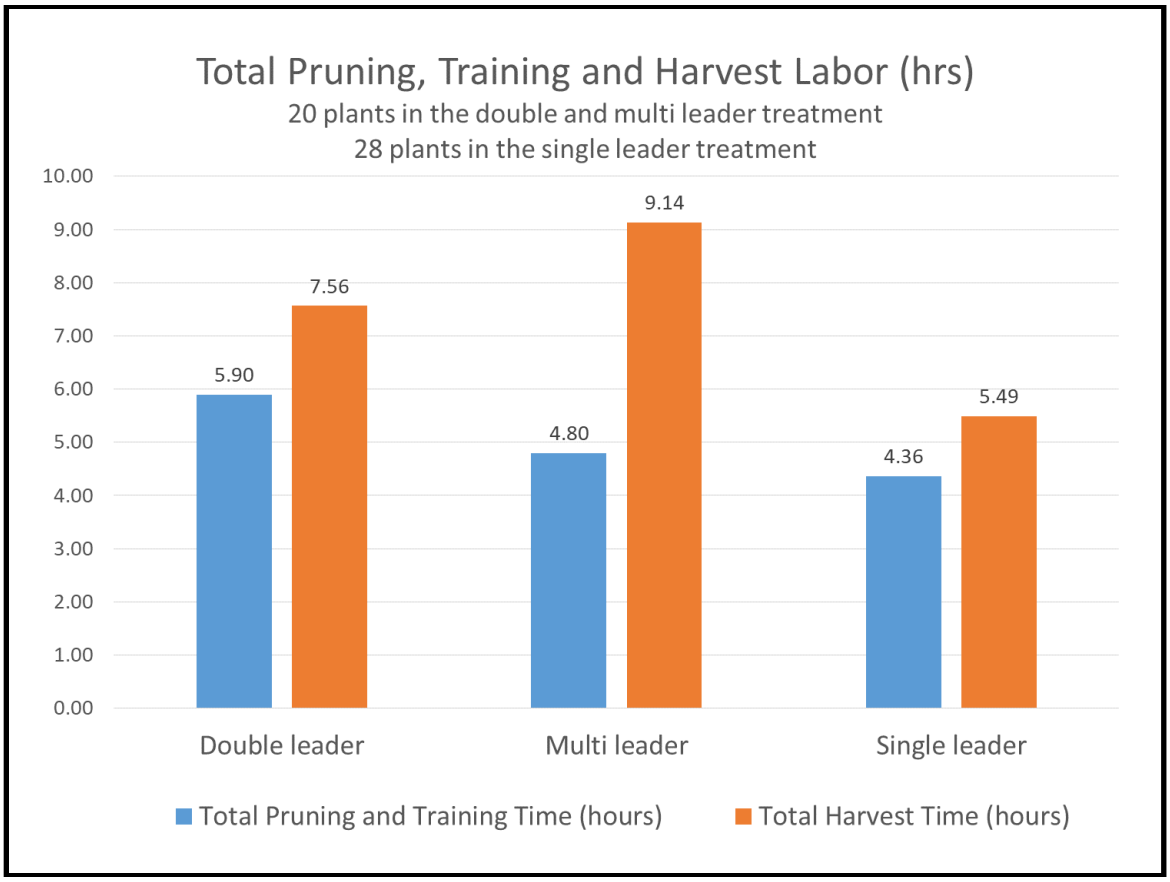

Figure 1. Pruning and harvest labor in 3 cherry tomato pruning regimes

Figure 2. Pruning to a Strong Y for a double leader system.

Figure 3. A double leader system

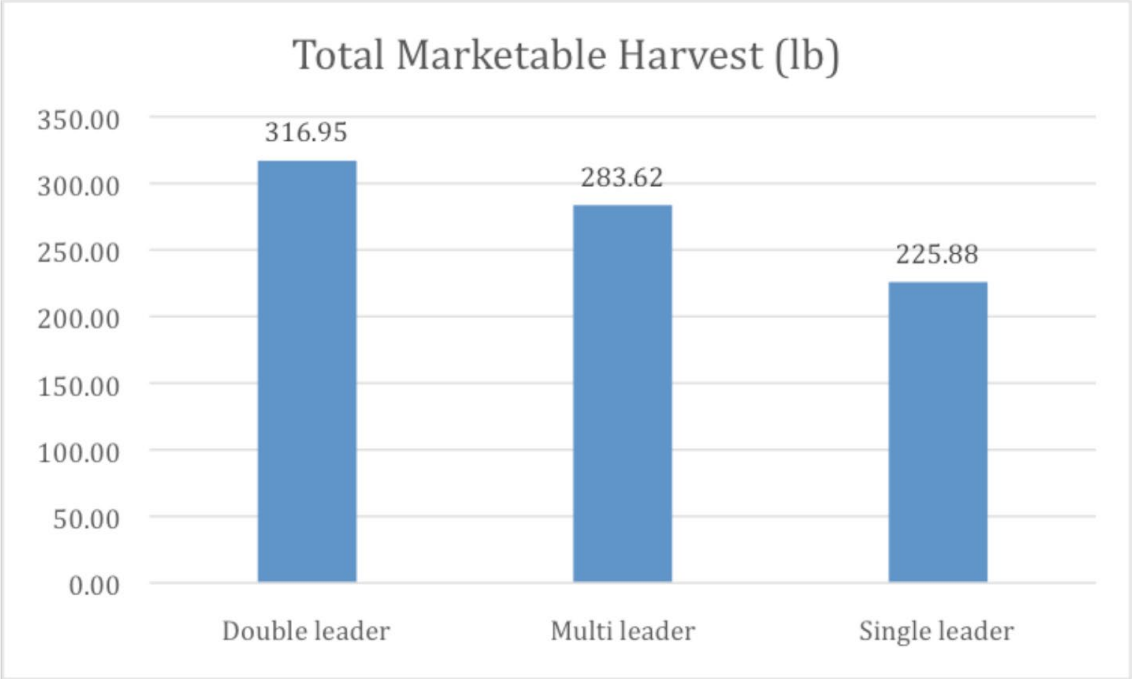

Figure 4. Average yield on 11' beds of cherry tomatoes under three pruning regimes.

With funding from the Northern New York Agricultural Development Program. Funding for the Northern New York Agricultural Development Program is supported by the New York State Senate and administered by the New York State Department of Agriculture and Markets.
Learn more at www.nnyagdev.org

Tomato Disease Management in High Tunnels and Greenhouses

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Early season issues are primarily abiotic:

- **Cold air or soil temperatures:** Symptoms include leaf spotting/damage and/or purpling of foliage. Check new growth-if it looks good and undamaged this indicates the roots are vigorous and the plant is recovering. If the new growth looks poor, check the root system for rot. https://www.uvm.edu/sites/default/files/UVM-Extension-Cultivating-Healthy-Communities/PDC_HighTunnelTomatoDiseases.pdf
- **Ethylene damage:** Symptoms include curling and twisting of foliage that seems to occur all at once. Check for cracked or poorly vented heaters. New growth should grow out healthy once the source of ethylene is identified and eliminated. Damaged tissue will not recover. If these symptoms occur later in the season, check for broad mites, pesticide contaminated compost or virus diseases.
- **Edema:** Corky lesions appear on leaf undersides, sometimes on upper side or along veins. Too much water during cloudy cool weather. The plant will grow out of it and new growth should look good once conditions have changed.
- **Damping off/crown rot:** The main infectious disease problem early in the season is damping off or crown rot. Several soil borne fungi attack roots causing wilt and poor vigor. These fungi are in all soils and prefer cold, wet conditions. New growth would look poor. Always look at the roots first. If they are brown and sloughing off, start over with clean flats and soil. Heat mats, good sanitation and Rootshield® may help. Crown rot shows the same upper plant symptoms as damping off but roots tend to look ok while the stem at the soil line is constricted or rotted from cool wet soils. New growth not would not be ok.

Later season diseases: Foliar: High tunnel tomatoes do not typically get the same leafspot diseases (Septoria or Alternaria/early blight) as field-grown tomatoes since they are protected from rain and leaf wetness. You may see some of these field diseases if you have dripping condensation or in the rows along the edges that are exposed to the weather. High tunnel tomatoes are susceptible to a variety of fungal diseases that thrive in high humidity. To avoid these diseases maintain humidity below 85% through use of fans, rolling up sides, open ends and open top vents. Prune lower leaflets and increase space between plants.

- **Botrytis/gray mold:** Prefers high humidity and will attack dying tissue and old flower blossoms. Fine gray spores are obvious on the affected parts. 'Ghost spotting' may occur on fruit. Lower humidity, clean up dead tissue.
- **Leaf mold:** Prefers high humidity and causes yellow "polka dotting" on the upper leaf surface and on the underside of the leaf you will see the gray/purplish spores of the fungus. Lower humidity and choose resistant cultivars.
- **Powdery mildew:** Specific to tomatoes only. (Powdery mildew will not travel from cucumbers to tomato, although you may see it on both crops if the conditions are conducive.) Symptoms include white spores on the leaf surface. Hard to keep up with the disease if it occurs early in the season. Keep new tissue protected with fungicides at first sign. Inspect transplants before introducing into the greenhouse. Fungicides include those containing sulfur, copper, chlorothalonil, oils (stylet, sesame, rosemary, thyme); plant extracts (Regalia®), biocontrol microorganisms (including sp. of Bacillus and Streptomyces) and potassium bicarbonate (Milstop®). Fungicides should be applied weekly to maintain control. The powdery mildew pathogen will not live in the greenhouse or on dead tomato refuse; it will only survive on a live tomato host.
- **Late blight:** Symptoms include large patches of dead tissue with spores visible on the lesion edges during high humidity. High tunnel tomatoes will not escape the disease if humidity is high and inoculum in the area is prevalent. Subscribe to Extension newsletters or check USA Blight (https://usablight.org/2019-map/) to see if the disease is in the area. Pathogen does not overwinter in VT. Lower humidity and protect plants with fungicides.
- **Cold air or soil temperatures** can cause leaf spotting/damage and/or purpling of foliage. Check new growth-if it looks good and undamaged this indicates the roots are vigorous and the plant is recovering. If the new growth looks poor, check the root system for rot. https://www.uvm.edu/sites/default/files/UVM-Extension-Cultivating-Healthy-Communities/PDC_HighTunnelTomatoDiseases.pdf
- **Blossom end rot**: Symptoms include dead, brown portions on blossom end of fruit due to imbalance of water, calcium and other nutrients. Even out watering. The second set of fruit is usually fine. Heirloom tomatoes may be more prone to this disorder. Dead areas of the tomato may become covered with black sooty spores due to secondary infections.
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- **Magnesium deficiency:** Symptoms include interveinal foliar yellowing in the lower part of the plant. Common in mid/late season. Prune up to first cluster. This rarely results in yield reduction and does not indicate a soil deficiency but is related to high potassium availability or poor root development. This makes the plant unable to take up sufficient

Mg, forcing the plant to move Mg from old leaves to the new. Magnesium deficiency is corrected by applying an Epsom salts fertilizer (magnesium sulfate) through the drip or watering directly onto plant rows but is typically not warranted. https://www.uvm.edu/vtvegandberry/factsheets/OrganicGreenhouseTomatoNutrition.pdf

Cankers: Symptoms include wilting in the tops of plants that typically do not recover during the night. Leaf edge scorch/browning common. Check lower in the plant.

- **Sclerotinia/white mold:** Fluffy white mold at the base of the plant typically in wet or poorly drained areas in the tunnel causing a brown canker and wilt. Black hardened sclerotia that look like mouse droppings may be within the mold or in the stem. Sclerotia can live several years in the soil. Cut off plant at base, remove and destroy.
- **Bacterial canker**: May see black lesions on the stems, wilting and/or severe leaf scorch. Cut into the vascular tissue just under the skin of stem to look for browning. Remove plant, watch neighboring plants for development of symptoms. Very easily spread through suckering and pruning. Purchase only hot water treated seed. Get a positive ID from your Diagnostic Clinic. DO not reuse clips or string without sterilizing before use again.
- **Alternaria**: This leaf spotting fungus can also cause stem cankers if conditions are wet or very humid in the house. Cankers typically have a bull's eye appearance.
- **Botrytis/gray mold**: If conditions are very humid, this fungus can cause stem cankers. You should see the diagnostic gray fuzzy spores on the lesion. Clean up infected fruit and stems.

For help with disease and pest identification and management, contact the Plant Diagnostic Clinic at your university.

Maximizing Varieties of Cherry Tomatoes for Flavor and Popularity for all Types of Marketing

Kim Atkins
Pleasant Valley Farm
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Pleasant Valley Farm was started in 1988 by my parents, Paul and Sandy Arnold. We are Certified Naturally Grown and grow over 40 different types of fruits and vegetables on about 5 acres, selling year round at farmers' markets and to a few wholesale accounts. Tomatoes have always been in our top ten profitable crops and cherry tomatoes are a specialty for us. We aim for growing the best tasting and best disease resistance varieties, along with best producing. We are always trying new varieties and comparing, which is how we ended up doing 30 varieties this year. We grow tomatoes in the field and in a high tunnel, though for the trial we focused on the field.

Our plants are started mid April in strip trays in the greenhouse, transplanted to 50 cell winstrip trays, then planted outside around June 1st. We trellis them using the basket weave style, planting them 1 row, 18" between plants on a 30" bed covered with biodegradable plastic and straw between rows.

In a typical year, we grow 15 cherry tomato varieties that span 9 different colors. In the trial, we grew 30 different varieties that spanned 14 different colors. We were able to trial a few varieties that haven't been available yet to many farmers, including Green Bee and Citrine. The tomatoes were judged on taste, size, disease resistance, holding on the vine and off, and earliness of first ripe tomatoes.

Some varieties that stood out were Orange Paruche, Green Bee, Brad's Atomic Grape, White Cherry, Black Cherry, Sweet Treats, and Sungreen Improved. Orange Paruche held well both on the vine and off, and had the sweetness of a Sungold plus more flavor. White Cherry, one of our main varieties every year, still stood out for both color, holding ability and flavor. Black Cherry, another main variety, has great flavor and looks really nice in a mix. The Sungreen Improved was a brand new trail that edged out its predecessor, Sungreen, in flavor and sweetness, though it was harder to tell when it was ripe. Brad's Atomic Grape is a large, slightly tough, beautiful cherry tomato that had a very interesting flavor that everyone liked. Sweet Treats is the favorite of many workers since it has great flavor, good holding on the vine, and fills a basket fast with its size and productivity.

Green Bee is perhaps the most interesting. It was bred in California by Fred Hempel of Artisan Seeds. It is a cross between a Sungold, The Blush and several other high flavor and long shelf life tomatoes. While we didn't test its long shelf life, it is supposed to be able to hold for several weeks. It has a tough exterior that if you aren't expecting it, is a turn off. The flavor is fantastic when it's ripe, especially when you prepare it the way it is meant to be: grilled.

As we harvest, we pick specific amounts of each color for each crate to create a nice color mixture, but not filling too full so as to avoid crushing the bottom tomatoes. We then dip the crate in water to both wash and mix the tomatoes. The tomatoes for market are put into half pint baskets that are sold for $3.50 or $4 depending on our market. Wholesale are either placed in pints, quarts or cardboard trays. As we fill containers, we sort out splits and they are either sold to a restaurant or we use them to make spaghetti sauce.

NEVF

New England Vegetable & Fruit

CONFERENCE '19

December 10, 11 & 12, 2019

Double Tree by Hilton downtown Manchester, NH

Sponsored by the Cooperative Extension Systems of:

Universities of Connecticut, Maine, Massachusetts,
New Hampshire, Rhode Island, Vermont,
Cornell University,
Connecticut Agricultural Experiment Station,
Maine Orgnic Farmers and Gardeners Association

New England Vegetable & Berry Growers' Association,
and Massachusetts Fruit Growers' Association

U.S. DEPARTMENT OF AGRICULTURE COOPERATIN G .

General Information

Tuesday Morning Sessions

Tuesday Morning Farmer to Farmer

Tuesday Afternoon Sessions

Tuesday Late Afternoon Farmer to Farmer

Tuesday Evening

Wednesday Morning Sessions

Wednesday Early Afternoon Farmer to Farmer

Wednesday Afternoon Sessions

Wednesday Late Afternoon Farmer to Farmer

Student Poster Session

Wednesday Evening

Thursday Morning Sessions

Thursday Afternoon Farmer to Farmer

Thursday Afternoon Sessions

Greetings and Salutations

Welcome to the 22nd New England Vegetable and Fruit Conference and Trade Show. This meeting takes place every other year in December, and includes more than 30 educational sessions over 3 days. Topics include major vegetable, berry and tree fruit crops, and much more.

Farmer-to-Farmer meetings throughout the conference allow you to discuss specific issues in more detail. There is also an extensive Trade Show with over 120 exhibitors. We hope that you will enjoy your time here, and meet with fellow growers, advisors, researchers and industry representatives. We want you to leave with new ideas and information that will have a positive impact on your farm.

This conference is special because it is put together with close collaboration between growers and Extension from across the region. The steering committee gathers the best speakers from within our region and across the country to tell you about the latest innovations and advances in vegetable and fruit production. Almost every session includes both farmers and research or extension personnel, so you are getting the "best of both worlds."

The New England Vegetable and Fruit Extension team also collaborates to conduct research, hold other educational programs, and to create resources for the benefit of growers. These include the New England Vegetable Management Guide, the New England Small Fruit Management Guide, and the New England Tree Fruit Management Guide which are published every other year. For more information about New England Vegetable and Fruit Extension Programs contact your state Extension office.

Our sponsors invite you to visit the Trade Show during the conference. We invite businesses and organizations to exhibit at the Trade Show for the purpose of providing information to the participants. While we make responsible efforts to assure the integrity of the exhibitors, the conference sponsors do not guarantee or warranty any product exhibited; neither do the sponsors imply approval of or endorse any product to the exclusion of others that may be available.

We value your feedback! We use your comments and suggestions to plan the next program. Please fill out an evaluation form before you leave!

newenglandvfc.org

2019 New England Vegetable & Fruit Conference & Trade Show

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Pesticide Education Credits

Certified pesticide applicators from New England are eligible to receive recertification credit. Growers from New York are NOT eligible to receive pesticide recertification credits. Pick up a form during registration and complete the information on the top portion. Be sure to have your certification number with you. This form is to be used for the entire conference. To get credit for a session, you must attend the entire session and forms must be signed by the Session Moderator at the end of the session. Turn in both the pink and yellow copies of the form at the registration desk when you leave the conference and keep the white copy for your records.

Certified Crop Advisor: Continuing Education Units

Certified Crop Advisors who attend certain sessions are eligible to receive Continuing Education Units. A sign in/out sheet will be available for each session in the room. CCA members must SIGN IN at the beginning of each session and SIGN OUT at the end of the session. You must attend the entire session to receive credit. Be sure to include your CCA membership number.

*Credits are awarded in topic areas. Credits are listed by topic area under the heading for each session. **Topic areas are: Nutrient Mgt., Soil & Water Mgt., IPM, Crop Mgt., and Professional Development.** Credits will be listed in that order (e.g., # Nut. Mgt credit, # S&W Mgt credit, # IPM credit, # Crop Mgt credit, # PD credit) and also provided as a list in registration packets.

Farmer to Farmer Sessions

What are farmer to farmer sessions? They are informal "chat" sessions where farmers learn from farmers and other knowledgeable presenters. There will be very short or no presentations at these sessions. Farmers can brainstorm and talk about what works for them and what doesn't, while learning new ideas from all who attend these roundtable discussions.

Why should I attend? Much can be learned from a mixed group of farmers, presenters, Extension people, researchers, and other interested folks. It will allow you a chance to ask questions of presenters and also of those who have experience in farming. These sessions have been very popular and successful, so come help and make these sessions a success for everyone again.

Have any photos? For any topic, bring photos, videos, a favorite tool, etc.

NEW EVENTS!

Culinary Breeding Variety Tasting Event: Come to this exciting event, where you can taste and compare diverse winter squash and carrot varieties developed specifically to have superior culinary appeal.

Student Poster Session: We've introduced a poster session for students who have been conducting relevant research that you might want to know about at one of our collaborating institutions. Check them out in the Assembly Area outside the Ballrooms!

Lunch

Each day of the conference, a selection of lunch offerings featuring local ingredients will be set up near the Trade Show exhibition hall and in the 'Cafe on the Park' near the lobby. In partnership with the Radisson Manchester Downtown, the New England Vegetable & Fruit Conference Steering Committee has made an effort to source locally grown ingredients from producers in all six New England states. Lunch and refreshments will also be available at 'JD's Tavern', 'The Daily Brew' and at many restaurants nearby in downtown Manchester.

Social Mixer and Awards Program

On **Tuesday** evening, the Trade Show is sponsoring a social from 4:30-to 6 pm. Light hors d'oeuvres and non-alcoholic beverages will be provided.

On **Wednesday** evening, the Conference is sponsoring a social mixer and awards ceremony from 6:00 to 7:30 pm with cash bar and light hors-d'oeuvres. The purpose of this event is to bring everyone together including guests from various state Departments of Agriculture and the New England Land Grant Universities. There will be a short speaking program that will include a brief awards program for the New England Vegetable Berry Growers Association to honor outstanding contributors for local agriculture. The cost of this event is covered by the Conference and Industry supporters of local agriculture. All are invited to this free event. Dinner will be on your own.

NEW ENGLAND VEGETABLE & BERRY GROWER'S ASSOC.

NEVBGA

The New England Vegetable & Berry Growers Association (NEVBGA) is the oldest vegetable growers association in the United States. We support and promote the vegetable and berry industries in New England.

The Association is a co-sponsor of the New England Vegetable and Fruit Conference. Made up of farmers and research and Extension personnel from Universities and Industry, we provide educational programming, publications, and networking opportunities for growers of all scales and production practices. We also support University research projects relevant to New England growers. You are invited to become a member!

We are offering a REDUCED RATE on Association dues for
FIRST TIME MEMBERS attending the CONFERENCE!!
Visit us at our table by the registration booth.

2019 NEVF CONFERENCE at a GLANCE

December 10,11,12 - 2019

Date/Time								Expo Center
Tues 9:30am-noon	Cucurbits, Pumpkins & Gourds	Tree Fruit I	Cover Crops	Strawberry I	Root Crops		F2F: Tips & Tales of Farm Transitioning	
Tues 12:00-1:45pm	Extended lunch: network & visit the trade show!							TRADE SHOW
Tues 2:00-4:30pm	Specialty Veg Crops	Tree Fruit II	Climate Adaptation	Strawberry II	Sweet Corn	No-Till	F2F: World of Seeds	
Tues 4:45-5:45pm	F2F: What's New in Insect Management		F2F: Climate Change Adaptation	F2F: Organic Strawberries			F2F: Culinary Breeding	Trade Show Social (4:30-6:00)
Tues 6:00-9:00pm		Irrigation Technology Focus Group	Worker Protection Standards Training					
Wed 9:30am-noon	Soil Health	Stone Fruit	Winter Growing	Brambles	Eggplant & Peppers	Specialty Nuts & Fruits		
12:00-12:45	Lunch							
Wed 12:45-1:45pm		MFGA Annual Meeting 12:00 - 12:45	F2F: Winter Growing			NEVBGA Exec. Comm. Meeting 12:00 - 1:30		TRADE SHOW
Wed 2:00-4:30pm	Alliums	Cider & Cider Apples	High Tunnels	World of Weed Mgt	Table Grapes	Cut Flowers	F2F: All About Wash/Pack & Sanitation	
Wed 4:45-5:45pm	F2F: What's New in Disease Management	F2F: Equipment (medium to large)	STUDENT POSTER SESSION					
Wed 6:00-7:30pm			Social Mixer and Awards Program					
Thurs 9:30am-noon	Blueberry I	Post Harvest Tools & Tips	Organic Production	Wildlife Control	Specialty Salads	Fruit Technology		
12:00-12:45	Lunch							
Thurs 12:45-1:45pm		F2F: Technology for farms--What's out there	F2F: Bio-Rationals					TRADE SHOW
Thurs 2:00-4:30pm	Blueberry II	Brassicas & Leafy Greens	Optimizing Water Use	Farming for Profit	Tomatoes			

Special Session	Farmer 2 Farmer Sessions	Regular Sessions	Special Meetings	All-Conference Meetings

Tuesday Morning - December 10, 2019

Cucurbits, Pumpkins and Gourds

9:30 **3 Years of Melon Variety Trials at Highmoor Farm, ME**
Nick Rowley, UMaine

10:00 **Managing Multiple Diseases in Cucurbits: Fungicide Update**
Meg McGrath, Cornell University

10:30 **Growing Pumpkins & Squash Organically & Conventionally in the Pioneer Valley**
Wally Czajkowski, Plainville Farm

11:00 **Pumpkin Weed Management Issues and Updates**
Bryan Brown, NYSIPM

11:30 **Summer Squash, Zucchini, Cucumbers, and Melons at Pomykala Farm: Small Scale Production and Sales Techniques**
Ben Pomykala, Pomykala Farm

Tree Fruit I

9:30 **Developing a Cost-sharing Program to Encourage the Adoption of Integrated Pest and Pollinator Management (IPPM) in Apples**
Anna Wallingford, University of New Hampshire Extension

10:00 **Herbicide Weed Control Strategies in Orchards**
Robert Crassweller, Penn State University

10:30 **Apple Fruit Rots… An Increasingly 'Bitter' Experience**
Sara Villani, Mountain Hort Crops Res and Ext. Ctr. N. C. State Univ.

11:00 **A Vision for Orchards of the Future**
Terence Robinson, NY Agr. Expt. Sta.

11:30 **Advantages of Two Leader Trees**
Bill Pitts, Wafler Nursery

Cover Cropping & Rotations

9:30 **Pros, Cons, Costs of Grass Covers between Rows**
Lisa MacDougall, Mighty Food Farm

10:00 **Mechanically Interseeding Covercrops**
Skip Paul, Wishingstone Farm

10:30 **Rotating Covers and Wholesale Leafy Greens**
Brent Preston, The New Farm

11:00 **Equipment we use to Manage Cover Crops, from Seeding to Incorporation**
Justin Rich, Burnt Rock Farm

11:30 **Effective and Efficient Interseeding of Cover Crops between Plastic Mulch for Weeds and Soil Building**
David Greenberg, Abundant Acres Farm

Strawberry I

9:30 **Getting Started in Strawberries Pt 1**
David Handley, University of Maine

10:00 **Getting Started in Strawberries Pt 2**
David Handley, University of Maine

10:30 **Ways to Extend your Production Season**
Charlie Gray, 4 Corners Farm

11:00 **Irrigation Innovations for Strawberries**
Trevor Hardy, Brookdale Farm

11:30 **Fine-Tuning Strawberry Nutrition**
Nate Nourse, Nate Nourse Consulting

Root Crops

9:30 **Managing Wireworms in Root Crops**
Teresa Rusinek, Cornell Cooperative Extension

10:00 **Beating Common Beet Issues**
Robert Hadad, Cornell Cooperative Extension

10:30 **New Root Crop Varieties for Improved Pest Management**
Jan van der Heide, Bejo Seeds

11:00 **Producing High Quality Carrots at Competitive Prices**
Andre Cantelmo, Heron Pond Farm

11:30 **Growing and Marketing Specialty Root Crops at Juniper Hill Farm**
Adam Hainer, Juniper Hill Farm

Farmer to Farmer

9:30 **Tips & Tales of Farm Transitioning**

Tuesday Afternoon - December 10, 2019

Specialty Vegetable Crops

2:00 **Growing Ginger in Tunnels**
Sue Decker, Blue Star Farm

2:30 **Medicinal Plants**
Wendy Fogg, Misty Meadows Herbal Center

3:00 **Saffron**
Margaret Skinner, University of Vermont

3:30 **Seaweed in New England**
Sarah Redmond, Springtide Seaweed

4:00 **Globe Artichokes and Belgian Endive**
Abigail Maynard, Ct. Agric. Exp. Sta.

Tree Fruit II

2:00 **Fighting Fire Blight: Using the Whole Playbook**
Dan Cooley, University of Massachusetts

2:30 **Managing Plum Curculio in Orchards with 'Attract and Kill' and Beneficial Nematodes**
Jaime Pinero, University of Massachusetts

3:00 **A Vision for Crop Load Management**
Terence Robinson, NY Agr. Expt. Sta.

3:30 **How to Raise Fruit in a Changing Climate**
Robert Crassweller, Penn State University

4:00 **The Move to High-Density Production Systems-- World-wide**
Win Cowgill, Ceo Win Enterprises International LLC

Climate Adaption & Resiliency

2:00 **Examining the Role of Extreme Rainfall in Phosphorus Losses from Agricultural Watersheds**
Tony Buda, USDA ARS in Pennsylvania

2:30 **Ag-Radar – Using Weather to Inform Pest Management**
Glen Koehler, University of Maine

3:00 **Organic Weed Management in a Changing Climate**
Sonja Birthisel, University of Maine

3:30 **Stress Mitigation in Vegetable and Small Fruit Crops**
Gordon Johnson, University of Delaware

4:00 **Up Your Adaptation Game With the Climate Adaptation Fellowship: A New Program for Vegetable and Berry Growers & Ag Advisors**
Rachel Schattman, University of Vermont

Strawberry II

2:00 **Cultural Weed Management for Strawberries**
David Handley, University of Maine

2:30 **Strawberry Herbicide Update**
Thierry Besancon, Rutgers Agricultural Experiment Station

3:00 **Soil Born Diseases**
Alicyn Smart, University of Maine

3:30 **Strawberry Breeding and Promising Selections from Nova Scotia**
Beatrice Amyotte, Agriculture and Agri-Food Canada

4:00 **Managing PYO Customers at Tougas Farm**
Andre Tougas, Tougas Farm

Sweet Corn

2:00 **Sweet Corn Insect Identification and Management**
Marion Zuefle, New York State Integrated Pest Management Program, Cornell University

2:30 **Producing Early-season Sweet Corn Using Black Plastic Mulch and Transplants**
Eric Peterson, Cold Spring Brook Farm

3:00 **Sweet Corn Weed Control**
Mark VanGessel, U of Delaware

3:30 **Selecting Sweet Corn Cultivars and Planting Dates for CSA and Wholesale Markets**
Bruce Gresczyk Jr, Gresczyk Farms

4:00 **An Update on Sweet Corn Variety Trials**
David Handley, U of Maine

No Till

2:00 **Tarping Cover Crops for Organic No-Till**
Natalie Lounsbury, University of New Hampshire

2:30 **Two Years of Tarping Trials on Our Farm**
Gillian Files, The New Farm

3:00 **Dawn ZRX Roller Crimper Planters**
Chad Cochrane, NRCS

3:30 **5 Years of No-till with Sweetcorn, Pumpkin, String Beans!**
Adrien Lavoie, Lavoie's Farm

4:00 **15 Years of No-till Sweetcorn**
Andrew Frankenfield, Frankenfeld Farm & Penn State Extension Educator

Farmer to Farmer

2:00 **World of Seeds**

Trade Show Social

4:30 - 6:00

Farmer to Farmer

4:45 **What's New in the World of Insect Mangement**
4:45 **Climate Change Adaptation**
4:45 **Organic Strawberries**
4:45 **Culinary Breeding**

Special Sessions

6:00 **Irrigation Technology Focus Group**
6:00 **WPS Training with Andrea Sylvian - EPA**