High and Dry

Growing Vegetables in Northern New England High Tunnels

THE UNIVERSITY OF VERMONT EXTENSION

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WELCOME to the fourth issue of *High and Dry: Growing Vegetables in Northern New England High Tunnels,* a quarterly newsletter linking growers, researchers, and agricultural service providers to enhance protected crop production. This issue focuses on pest issues you may have seen last season or are likely to experience in your high tunnel crops over the winter growing season.

This online newsletter is a collaborative effort among the University of Vermont (UVM), the University of New Hampshire (UNH), and others to support high tunnel growers — especially new ones who are still gaining experience with this technology. Our goal is to provide information and resources to help your high tunnel crops thrive!

Don't hesitate to reach out to the team listed on the last page with any questions or ideas for future topics. This work is funded by the Northeast Sustainable Agriculture Research and Education (NE-SARE) program and the UVM and UNH Extension programs.

Preparing High Tunnels for Extreme Weather

Although high tunnels and greenhouses provide protection for crops from rain, wind, and other erratic weather, climate change brings both a higher frequency and increased intensity of extreme weather events. It is important to think about how high tunnel structures can best be built and modified to endure these extremes. The article "Preparing High Tunnels for Extreme Weather," compiled by Chris Callahan, Becky Maden, and Vern Grubinger of UVM Extension is an excellent summary of experiences shared by the growers of the Vermont Vegetable and Berry Growers Association (VVBGA). Read it here:

https://go.uvm.edu/ht-weather

High Tunnel Topics at the 2024 New England Vegetable and Fruit Conference, December 17-19

Heather Bryant, UNH Extension

Registration is open for the New England Vegetable and Fruit Conference which is held every two years in Manchester, N.H. This year's schedule offers interesting topics for tunnel growers across the range of sizes and experience levels. We also have a jam-packed agenda that will touch on fruit and vegetable production outside of the tunnel and a trade show with over 120 exhibitors. It's all going to be good!

Visit **https://newenglandvfc.org/** for more information and to register.

Here's a list of topics and sessions of particular interest to tunnel producers:

Tuesday, December 17	
9:30 a.m. – 12 p.m.	Cut Flowers
Wednesday, December 18	
9:30 a.m. – 12 p.m.	Tomato
12:45 – 1:45	Farmer2Farmer Sessions:
	• High Tunnel Tomatoes
	• Greenhouse Setups & Seedling Production
2:00 – 4:00	Leafy Greens & Specialty Vegetables
4:45 – 6:00	Farmer2Farm Session: Leafy Greens
Thursday, December 19	
9:30 a.m. – 12 p.m.	Winter Growing
12:45 – 1:45	Farmer2Farmer Session: Winter Growing
2:00 – 4:30	Protected Culture

On Tuesday, the "Cut Flowers" session (9:30 a.m.) will include a talk about high tunnel cut flower production.

During Wednesday's "Tomato" session, Dr. Cheryl Frank Sullivan will talk about strategies to avoid aphid outbreaks in tunnels. We will also talk about grafting greenhouse tomatoes and managing tomato tunnel fertility. During the "Leafy Greens & Specialty Vegetables" session you can learn about year-round microgreen and shoot production.

Thursday's "Protected Culture" was designed around the comments we received from tunnel producers who attended last year's High Tunnel Conference in Lebanon, N.H. This session will cover tunnel construction and siting considerations, high tunnels and water management in a changing culture, a high tunnel gantry system, and the do's and don'ts of gutter connected Haygroves. The "Winter Growing" session will feature Catherine Sylvestre talking about profitable winter green production in Canada.

We hope to see you there!

What's That Bug?

Cheryl F. Sullivan, University of Vermont
Entomology Research Laboratory

We have been seeing some interesting natural enemies visiting the alyssum habitat hedges we established along the outside of a few high tunnels this past summer. One of these visitors was *Trichopoda pennipes*, a feather-legged fly, which is a tachinid. Tachinids are one of the largest groups of flies and unlike many other tachinids that are hairy, drab in their coloring, and resemble houseflies. However, this fly is less hairy and boasts a bright orange color. The larvae are parasitoids of several crop pests, particularly leaf-footed bugs (like squash bugs) and stinkbugs.

Swift feather-legged fly. (Photo: Cheryl Sullivan/UVM)

Green Stink Bug
(Photo: Alton N. Sparks, Jr., University of Georgia, Bugwood.org)

Green Squash Bug
(Photo: Kansas Department of Agriculture, Bugwood.org)

Join These Informative E-mail Lists!

VT-TIC

UVM Tick Information Center. Stay up to date with Tick Topics including news, research, and more from around the region.

Tunnel Vision

Receive the hottest new high tunnel info, stay in the loop about upcoming events, be informed when newsletters become available, and more.

Email Cheryl Sullivan at cfrank@uvm.edu with the subject line "subscribe" to join either or both lists.

Flea Beetles: Tiny Terrors in Your High Tunnels

Margaret Skinner, Somaiyeh Ghasemzadeh, &
Cheryl F. Sullivan, University of Vermont
Entomology Research Laboratory

High tunnels are great for protecting crops from unpredictable weather and extend the growing season on both ends of the season. *But* they also provide ideal conditions for pests. Heated high tunnels provide environments that encourage survival of insect pests which might not survive if they were outside. Even unheated high tunnels can moderate the frigid winter temperatures, enabling some species to make it through to the spring.

Flea beetles will likely overwinter successfully in a high tunnel, ready to pounce on the young seedlings when temperatures rise in the spring. The actions you take now to reduce overwintering populations will minimize their impact later.

FIG. 1: Flea Beetle (Photo: R. Ottens, Univ. of Georgia)

What are they? Flea beetles are tiny beetles, generally less than ¼ inch long, in the leaf beetle family, Chrysomelidae. However, they are *not* closely related to fleas! Their name comes from the adults' habit of jumping at the slightest disturbance. Their hind legs have an enlarged femur with a special spring that gives them the hop. They are the bane of most growers because they seem to show up in large numbers and without warning. It is difficult to get rid of them, partly because they move so fast.

There are 72 different species of flea beetles. Most are a shiny metallic color — often bright blue, black, or green, and sometimes brown or striped (fig. 1). Flea beetles are found in a variety of habitats including field and high tunnel agricultural crops, grape and fruit orchards, and landscape settings. This article is focused on flea beetles attacking vegetables in high tunnels.

Crop damage. Flea beetles feed on a wide variety of crops and show some species specificity. For example, the crucifer flea beetle *(Phyllotreta cruciferae)* favors brassicas. Spinach flea beetles *(Disonycha xanthomelas)* feed on spinach and beets. The striped flea beetle *(Phyllotreta striolata)* feeds on cabbage. And potato flea beetles *(Epitrix cucumeris)* and pale-striped flea beetles *(Systena blanda)* feed on potato, tomato, eggplant, and pepper.

FIG. 2: Flea beetle damage on lettuce (top), broccoli (center), larval damage on potato (bottom). (Photos: W. Cranshaw, CO State University, Bugwood.org)

Adults feed on leaves, creating tiny pits or small shot-holes (fig. 2). When they gather in large numbers, feeding causes extensive pitted or ragged areas. Seedlings and young plants are more vulnerable than mature plants because the leaf tissue is tender and succulent, and leaf area is limited. It doesn't take many flea beetles to consume the entire plant. Their damage can significantly reduce market value of foliage crops such as Swiss chard, kale, spinach, etc. Damage from flea beetle adults is reported to be the worst in spring when they emerge from overwintering sites. However, high populations have been observed by growers at other times of the year. Larvae can also harm crops later in the season. On carrots, they feed on the roots causing sunken spots, while they burrow into roots and stems on eggplants and potatoes. They are also believed to vector various plant diseases. In tunnels, potatoes may develop small, raised unsightly bumps.

Life cycle. Adults overwinter in the soil, and under plant debris or weed cloth. Overwintering can take place in or around the high tunnel, especially along the outside edges at the base of weeds. They emerge in spring when temperatures reach around 50°F, feeding first on weeds and then moving to crops when they are planted out. Eggs are laid in the soil at the base of the host plant. A female commonly lays around 60 eggs over a 3-week period. After 7 to 14 days, the eggs hatch into larvae, which feed on stems, leaves, and roots. Larvae feed for around 4 weeks

and then pupate in the soil in earthen cells. Adults emerge after 11 to 13 days and begin the cycle again. It is common for flea beetles to go through 1 to 3 generations each year.

Management Options

CULTURAL/MECHANICAL TACTICS. During late fall and winter, growers can expect minimal flea beetle damage as the adults are in their overwintering phase. However, now is when plant/crop debris should be removed to limit suitable overwintering sites. Eliminate weeds in and outside the tunnel — especially those favored by flea beetles such as mustard and wild solanaceous plants. Turn over the soil in the high tunnel during a fallow period. This will disturb and potentially kill overwintering flea beetles.

SCOUTING. Establish a routine high tunnel scouting program — even during the slow winter months — to make sure this pest doesn't overwinter in the soil. Yellow or white sticky cards are effective tools to monitor adult emergence in the spring. However, it is unlikely that sticky cards will reduce pest populations sufficiently to protect the crop. The downside of using these traps is they may also catch beneficial insects you want to protect.

If flea beetles have been a problem in the past, growing trap plants, such as radishes, can be used to attract them. It is important to check trap plants frequently and apply a treatment or remove them if large numbers of beetles are detected. Growers should maintain records of flea beetle occurrence in the field and high tunnel to predict the timing of future outbreaks. Thresholds for management action have been established for some crops. The thresholds for eggplant, for example, are: 2 beetles per plant for seedlings less than 3 inches tall, 4 beetles per plant for plants that are 3 to 6 inches tall, and 8 beetles per plant for plants over 6 inches tall. The threshold for foliage crops depends on the tolerance of the consumer.

TIMING OF PLANTING. In field settings where flea beetles are a common problem, planting out seedlings after the beetles emerge from overwintering is recommended. This is generally not an option in high tunnel production, where the goal is to produce a crop early.

FLOATING ROW COVERS. These mesh coverings are often used to protect many types of crops from flying pests, especially seedlings early in the season (FIG. 3). The covers are removed when the threat of the pest has passed or when pollination is required. Protecting young seedlings is recommended until they reach the sixth leaf stage. This strategy is excellent for excluding pests if they are sealed at the soil level and don't have holes. However, they are not without their problems. Natural enemies as well as the target pests are excluded and if the pest is already in the soil, instead of excluding them, the row cover will trap them in with the crop.

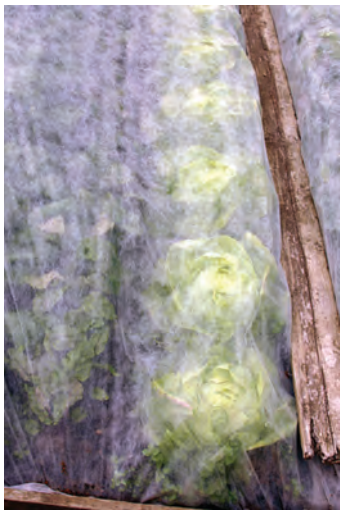

FIG. 2: Floating row cover in high tunnel. (Photo: S. Mahr, Univ. of WI)

The following beneficials may be critical for keeping flea beetles at low levels.

BIOLOGICAL CONTROL. Several generalist predators, including lacewings (*Chrysopa* spp.) and various predatory bugs are reported to feed on adult beetles. However, because flea beetle populations can migrate in from outside in large numbers, it is hard to believe they could effectively reduce the population below damaging levels fast enough. Commercial nematodes are reported to reduce flea beetle populations at the larval stage, but further work is needed to confirm that finding.

PESTICIDE CONTROL. Several products are registered for use against flea beetles. This topic will be covered in depth in a future issue.

FIG. 4: Assassin bug, a generalist predator that might feed on flea beetles. (Photo: J. Berger, Bugwood.org)

Useful references

Hoidal, N. 2020. Managing tricky vegetable insects in 2020: Flea beetles. **https://blog-fruit-vegetable-ipm.extension.umn.edu/2020/03/managing-tricky-vegetable-insects-in.html**.

Delahaut, K. with updates by D. Lowenstein and R. Groves. Flea Beetles. **https://vegento.russell.wisc.edu/pests/flea-beetles/** (great images of different species).

Kuepper, G. and R. Dufour. 2015. Flea Beetle: Organic Control Options. ATTRA Sustainable Agriculture. **https://ucanr.edu/blogs/capitolcorridorsmallorganicfarm/blogfiles/53415.pdf**.

Soil Steaming in High Tunnels For Pest and Weed Control

Becky Maden
UVM Extension Research Assistant Professor

A big advantage of high tunnels is that they enable year-round crop production, but tunnel environments are also conducive to weeds, insects, and pathogens, which can build up to damaging levels after several years of production. One way for growers to reduce weed and pest pressure in a high tunnel is by "steaming" the soil, which has the potential to eliminate or reduce problems without the use of any chemicals.

Soil steaming is a method of soil disinfestation that has been used since the 1800s in floriculture greenhouses, tobacco production, and other high value commodities. More recently, soil steaming has seen a resurgence in popularity as a tool which is effective in organic production and as an alternative to chemical fumigation following the EPA's phase-out of methyl bromide in 2005.

The goal of soil steaming in high tunnels is to pasteurize the soil and effectively eliminate harmful organisms while preserving helpful soil biology. Target greenhouse soil steaming temperatures — for most growers — are around 160°F. That is a temperature which can successfully control most plant pathogenic fungi and bacteria, slugs, nematodes, plant viruses, and weed seeds (see below). Temperatures exceeding 180°F can destroy good soil biology, alter soil chemistry, and harm soil structure. Steaming for less time and at lower target temperatures conserves fuel and allows a larger area to be steamed in a shorter time. Both time and temperature should be carefully adjusted, based on the targeted pest, to optimize fuel and time use.

Moist Soil, 30 Minutes	Organisms Killed
120°F	Nematodes
140°F	Most plant pathogenic bacteria and fungi
140°F – 160°F	Soil insects
160°F	All plant pathogenic bacteria; most plant viruses
160°F – 175°F	Most weed seeds
200°F – 212°F	Heat-resistant plant viruses and weed seeds

Source: Baker, K.F., 1957

There are several methods of soil steaming which may be used at larger scales. However, the method currently used by most growers in the Northeast is "sheet" or surface steaming. Steam is delivered from a steam boiler to the soil surface and travels from the boiler through a permeable "sock," which penetrates the soil via conduction. The size of the steam area differs based on the capacity of the steamer and target temperature, though typically ranges from 600 to 1,200 sq. feet.

Photo credit: David Paulk, Sassafras Creek Farm

Sheet steaming is time intensive. Depending on the steamer, it can take between 30 and 90 minutes to steam 600 sq. feet, or up to 7 hours for a 2,880 sq. foot (30' × 96') tunnel. Newer, larger steamers have the capacity to handle larger areas with less time involved. The steam calculator, developed by UVM Extension Agricultural Engineer Chris Callahan, is very useful in helping determine run time and steam size based on the specifications.

https://go.uvm.edu/steam

Northeast growers first adopted steaming by purchasing used low-pressure steamers, usually from areas where steaming had been used for tobacco seedling production. When purchasing a used steamer, make sure that the heat exchanger tubes are new because they leak over time.

New steamers are more efficient and easier to run. There are some steam units available for rental in the Northeast, which helps make steaming more accessible to small-scale farms. Nearly all of the units used for "sheet" steaming run on diesel fuel or kerosene and consume roughly 60 gallons for every 3,000 sq feet steamed. Though the amount of fuel depends on many factors, including beginning and ending soil temperature, steam unit used, soil moisture, etc. The steam calculator is also useful for estimating fuel use.

Steps for soil steaming

1. Prepare beds as if you are about to plant. The beds should be moist but not saturated. Do not disturb the soil after steaming.

2. Lay steam socks on the bed.

3. Cover the area with a tarp and secure with chains around perimeter.

4. Place temperature probes in several areas to monitor.

5. Steam at the target temperature for the desired duration; 30 minutes is usually recommended. Plan on each steam run to take a total of 90 minutes, which includes the set-up and run times. Factor an additional 30 minutes for the first run of the day to get the steamer up to temperature.

6. Use gloves to move the chains and set up the next plot. Do not walk on the beds during or after steaming. Wait at least 5 days to plant.

7. For more step-by-step soil steaming guidance, watch Becky Maden's steaming demonstration on YouTube.

https://www.youtube.com/watch?v=zR1PNx048Co

Bruce Wooster from Picadilly Farm lays out the steam sock. Photo credit: Becky Maden

Steaming to Control Chickweed

Common chickweed *(Stellaria media)* is one of the biggest problems for winter greens production in the Northeast. Chickweed is especially well adapted to growing in high tunnels. It is a winter annual that emerges primarily in the fall and sets tens of thousands of seeds after flowering (Michigan State Extension, 2022). Severe chickweed infestations can lead to significant or total economic losses in tunnels. Manual control of chickweed is difficult at scale and can be an expensive labor cost for tunnels with significant infestations. Many growers have found soil steaming to be one of the only available tools to control chickweed.

Research conducted by UVM Extension (Maden, unpublished) demonstrated excellent chickweed control using steam to maintain a soil temperature of 160°F at 2 inches deep for 30 minutes. This provided 95% control of chickweed compared to unsteamed control plots.

Steaming to Control Soilborne Pathogens

Steaming is used as a way to kill or reduce soilborne pathogens or pests such as root knot nematode, phytophthora, sclerotinia, fusarium, and pythium. In the UVM study (Maden, unpublished) steaming reduced damping off by 40% in direct-seeded spinach plots compared to control plots. Other research and anecdotal evidence suggests that steaming is a promising control of many pathogens, although more data is needed. In most cases, the recommended depth for the target steam temperature to control soil borne pathogens is 6 to 8 inches, depending on the specific pathogen and cash crop.

Effect of Steaming on Soil Health

There is a predicted decline in microbial activity immediately after steaming — even at lower steaming temperatures. The UVM research (Maden, unpublished) assessed the impact of steaming on soil microbial populations, showing that while there was an initial population decline, both the overall number and the diversity of microbes rebounded within 6 months of steam treatment.

It is recommended that growers proactively employ practices to boost soil biology after steaming through the addition of well-made compost and other "living" soil amendments such as cover crops and fresh chopped mulches. Additions of soil organisms such as *Tricoderma,* spp. may also be helpful in repopulating the soil with beneficials.

Costs vs. Return on Investment Related to Soil Steaming

In the UVM study that examined control of chickweed with steaming, the cost of soil steaming was estimated between $0.25 and $0.60 per sq. foot OR $600 to $1,700 per 2,700 sq. foot house, depending on the type of steamer and fuel costs.

Steaming reduced the cost of hand weeding chickweed between 30 and 60%. Depending on the level of pest or weed infestation, multiple years of control can be achieved with one steaming event, allowing farmers with multiple tunnels the ability to spread out the workload of steaming annually.

Conclusions

Soil steaming is a promising, chemical-free alternative for growers who have targeted pest issues that are challenging to address with other techniques, such as those faced by high tunnel growers. Although the cost of steaming is high, many growers find it worth the investment to produce reliable crops free of pests and weeds. Steamer technology continues to improve, which hopefully means even more options for growers in the near future. Soil steamers can be a good fit as a piece of shared equipment through a conservation district or group of growers.

Resources

To learn more about steaming, watch the following YouTube videos:

- "Steaming Tunnel Soils with Becky Maden," a Vt. Vegetable and Berry Growers Association (VVBGA) webinar recording
- "Soil Steaming Overview with Becky Maden, UVM Extension"
- "Soil Steaming with Becky Maden" on UVM Extension's Across the Fence

Steamer Purchases & Rentals:

- New: Sioux Steamer; Beresford, South Dakota
- Used: Harv Braverman; Ontario. Canada; (519) 879-6579 or (519) 281-1132
- Rental: Cheshire County Conservation District (N.H.)

References

- Baker, K. F. (Kenneth F., & Chandler, P. A. (Philip A. (1957). The U.C. system for producing healthy container-grown plants through the use of clean soil, clean stock, and sanitation. [Berkeley] University of California, Division of Agricultural Sciences, Agricultural Experiment Station, Extension Service.
- Michigan State University Extension. Common Chickweed. Retrieved October 27, 2022 from https://www.canr.msu.edu/weeds/extension/common-chickweed.

Please Complete the High Tunnel Survey

Collaborating researchers at the University of Vermont and University of New Hampshire, want to learn more about the practices you use and challenges you face in your high tunnel production. Your responses will help us design our future research and outreach programs to provide the best resources for improving nutrient and pest management. The survey should take about 10 to 15 minutes to complete and responses are anonymous.

Please go to the following link to complete the survey:

https://go.uvm.edu/ht-survey

Thank you for your help with gathering this critical information. If you have additional questions, please email Cheryl Sullivan at cfrank@uvm.edu.

Register Now for the Tri-state Greenhouse IPM Workshops!

The 2025 Tri-State Greenhouse IPM Workshops will be held on **Thursday, January 23 and 30, 2025** via Zoom. These workshops are for growers with greenhouses or high tunnels, Extension specialists, and professional pest managers. Growers of all experience levels are welcome to attend. Pesticide applicator recertification credits for attendees will be awarded. The Tri-State IPM Program is a collaboration among growers and specialists from Maine, New Hampshire, and Vermont. For more information and to register visit:

https://go.uvm.edu/ipm-workshops

Don't Miss USDA NRCS Funding Opportunities!

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) offers a variety of financial incentive programs that can support high tunnels and other practices on your farm. Get your paperwork done this winter so you don't have to deal with it during the 2025 growing season by visiting your local USDA service center. Go to the "Find Your Local Service Center" website to locate the offices in your state.

www.nrcs.usda.gov/contact/find-a-service-center

The USDA Farm Service Agency (FSA) will help you complete the paperwork needed to apply for FSA and NRCS programs.

Navigating the funding options out there isn't easy. Julie Callahan is the new UVM Extension Farmer Engagement Specialist who can help vegetable and fruit farmers connect with funding opportunities. Please reach out to Julie at Julie.Callahan@uvm.edu for help or to share your feedback on navigating (state, federal, or other) funding programs. In New Hampshire, contact your County based Field Specialist.

Late Blight in High Tunnels

Ann Hazelrigg, UVM Plant Diagnostic Clinic

Late blight *(phytophthora infestans)* showed up in Vermont in late summer 2024. This fungus-like pathogen does not overwinter in New England but blows in on storm fronts from the south. In some years, the disease never makes an appearance. However, if storm fronts and weather cooperate, the lightweight airborne sporangia can blow in from long distances "'leap frogging" its way up north.

The airborne sporangia "rain" down into fields during rain events and if weather is conducive (cool/humid/wet) infections rapidly spread in tomatoes and potatoes. There are strains of the pathogen that vary in their preference for tomato and potato, but the strain identified in the first outbreak this summer in Vermont was US23, which is aggressive on both crops.

Symptoms start as water-soaked spots with undefined margins on any aerial portion of the plant. Under humid conditions, a ring of whitish sporangia of the pathogen can often be on the outer edge of the lesion. The sporangia are blown onto healthy plants causing new infections if the weather is favorable. If the weather following an infection turns dry and hot, the pathogen will not die but will remain inactive until cool wet conditions flare activity. High tunnels may offer some protection from the disease but when inoculum becomes high in area fields, high tunnel tomatoes can become infected. The sporangia gain access through open sides and vents and can rapidly destroy a crop when there is high humidity in the tunnel.

The best way to manage the disease in a high tunnel is to rogue out and destroy infected plants and keep humidity low through heating and ventilating. Maintaining good plant spacing and the use of fans will help improve air circulation within the canopy and between plants to help lower humidity. Copper fungicides are listed as organic controls in tunnels but may not be worth the effort and expense of spraying and washing fruit for the limited efficacy they offer.

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NH Extension

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