UMass Extension

Vegetable Notes

For Vegetable Farmers in Massachusetts since 1975

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In this issue:

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Contact the UMass Extension Vegetable Program with your farm-related questions, any time of the year. We always do our best to respond to all inquiries. **Office phone:** (413) 577-3976 *We are currently working remotely but checking these messages daily, so please leave us a message!* **Email:** umassveg@umass.edu

Home Gardeners: Please contact the UMass GreenInfo Help Line with home gardening and homesteading questions, at greeninfo@umext.umass.edu.

Crop conditions

All of a sudden it feels like summer! March was warmer and drier than normal and folks have been taking advantage of relatively dry field conditions to get out and start doing some field prep like sub-soiling, plowing, seeding cover crops in fields that won't be used this spring, and cultivating fields of un-mulched garlic. The warm temps this week have made for good planting conditions and the fields are filling up fast with early corn, potatoes, early transplanted brassicas, beets, spinach, and chard, and directed seeded crops like radishes. Lots of activity in the greenhouse too, keeping up with seeding and watering schedules, and pests! See below for some common spring greenhouse problems, along with tips and resources for management.

Have a suggestion for a twilight meeting?

Click here to share your ideas!

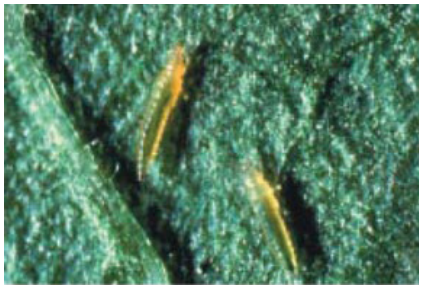
We are planning our twilight meetings for this season, so let us know if there are things you'd like to see in action, topics you want to learn about, farms you'd like to visit, or if you'd like to host a meeting and show off a new tool or technique or your own! Share your ideas with us using the blue button above. This season holds a lot of promise (COVID-19 seems to still be receding and the weather is cooperating so far) but there are still a lot of challenges (scarce labor, increased prices for supplies, fertilizers, and fuels, and another recent uptick in COVID-19 cases). New England farmers are a resilient and optimistic bunch, we are hoping that you all have a great season ahead, and we'll be here either way to help as best we can! As always, feel free to shoot us an email at umassveg@umass.edu or call 413-577-3976 if you have a question or issue this year.

Pest alerts

Seedling production is in full swing and reports of greenhouse pests and other issues are starting to come in. Greenhouse pests can be controlled with biocontrols or chemical controls, but sanitation measures and cultural controls are crucial strategies for achieving efficacy with either tactic. We recommend using yellow sticky cards to monitor what types of insect pests are present in your greenhouse. This resource from Leanne Pundt at UConn Extension is useful for identifying different greenhouse pests on yellow sticky cards.

Can I use this product in the greenhouse? If you plan to control for greenhouse pests using chemical controls, first check to make sure the product you'd like to use is labeled for use in a greenhouse! In Massachusetts, greenhouse use of a product is allowed *unless* the label specifically prohibits it. If a label does not mention greenhouse use, you may use that product in the greenhouse. For resistance management reasons, some products are not allowed to be used on plants grown for transplant. For, consult these tables in the New England Vegetable Management Guide to find insecticides or fungicides labeled for vegetable seedling production. For vegetable crops grown to harvest in a greenhouse or tunnel, Michigan State University has compiled a spreadsheet of greenhouse allowances for most pesticides, available here. If your product is listed as "certain crops, see label", we recommend searching a pdf version of the article for the word "greenhouse".

Thrips (several species may be present including onion, Western flower, and Eastern flower) are about 1/8" long and shaped like a tiny grain of rice. Nymphs are yellow or light brown, and often almost translucent. Adults are darker brown. Thrips pierce plant cells and suck out the contents, causing white or silver stippling and leaf distortion. They often leave round specks of shiny black frass (insect poop!) on the leaves. Thrips often survive year-round in greenhouses on weeds or are brought in on purchased plants, especially floriculture plants. Controlling weeds, raising floriculture and vegetable plants in separate greenhouses, and carefully inspecting incoming plants for thrips are all important management practices. Beneficial nematodes and/or predatory mites can also be used to keep thrips populations low – see the UMass Floriculture Program's Beneficial Nematodes for Biocontrol of Fungus Gnats and Thrips and Predator Mites for Biological Control of Thrips in the Greenhouse updates for more information.



*Western flower thrips nymphs (*Fankliniella accidentalis*)*

Aphids also feed on plant sap. In addition to the direct feeding damage the cause, they also exude a sugar substance called honeydew, on which a fungus called sooty mold grows. Honeydew and sooty mold do not directly harm plants but make them unmarketable and can reduce photosynthesis. There are many types of biocontrols for use against aphids – see our Aphid Biocontrol in High Tunnels article for more information.

*Green peach aphids (*Myzus persicae*) on a pansy leaf. Photo: A. Madeiras*

Leafhoppers are a less common greenhouse pest than thrips and aphids, but occasionally pop up on mint family crops like rosemary. Leafhopper feeding damage causes leaf stippling and flecking.

Leafhopper damage to rosemary, Photo: L. Pundt

Fungus gnats are tiny flies that feed on organic matter in potting mix, algae that may be growing on the surface of pots, and on plant roots. They thrive in wet environments, so it's important to avoid overwatering plants, especially during long periods of rainy or cloudy weather. Seed transplants into appropriate-sized trays to limit the amount of unnecessary wet potting mix around the plants. Fungus gnats can also be managed using beneficial nematodes – see link above.

Fungus gnats on a sticky card, photo: L. Pundt

Algae, mold, and damping off are other common results of overwatering. Algae will grow on the surface of potting mix, and while it does not harm seedlings directly, it can form a crust on the top of a pot or cell and limit gas exchange and water infiltration. Algae also creates a good environment for the proliferation of fungus gnats, who feed on the algae and thrive in the wet environment. See our Algae in Transplants article for more information. Fungi can also grow on the surface of potting mix; these fungi are growing on the organic matter in the potting mix and also will not directly harm the plants but can reduce water infiltration, similarly to algae. Damping off is a disease caused by several ubiquitous soil-dwelling fungi and fungal-like pathogens. These are weak pathogens that can only cause disease in young seedlings or when conditions are not favorable for vigorous plant growth. See the "In greenhouse transplant production" section of our Damping Off Diseases article for more information. To prevent all of these problems, avoid overwatering and seed into appropriately sized transplant cells. Train staff on how to water evenly, focusing on the outside edges of trays that dry out faster than the centers.

Allium leafminer oviposition marks on onion. Photo: E. Grundberg

Algae and fungus growing in a transplant tray due to large cells that remain wet for too long. Photo: S. Scheufele

Allium leafminer: Locations in eastern MA (Boston area and Cape Cod) are nearing or above the 350 GDDs base 1°C predicted emergence date for allium leafminer. Growers in this area with allium crops in the ground currently should scout for neat rows of round, white oviposition/feeding marks on allium foliage. Allium leafminer prefers onions, scallions, and leeks as host plants and does not usually prefer garlic. The rest of the state is at approximately 250 GDDs base 1°C and is not expected to reach the ALM emergence threshold for at least another week. For more information on allium leafminer damage and management and instructions on how to check the GDDs in your location, see our latest Veg Notes Pest Alerts email.

TARPING IN THE NORTHEAST – STALE SEEDBEDDING WITH TILLAGE AND TARPS

--Written by Natalie Lounsbury (University of New Hampshire), Sonja Birthisel (University of Maine School), Jason Lilley (University of Maine Cooperative Extension), and Ryan Maher (Cornell University)

Editor's note: The following is an excerpt from Tarping in the Northeast: A Guide for Small Farms, published this year by the University of Maine Cooperative Extension by the authors listed above. Access the full Guide here: https://extension.umaine.edu/publications/wp-content/uploads/sites/52/2022/03/1075-Tarping-Guide.pdf. See the full Guide for the list of works cited below.

Introduction

Reusable tarps, including black plastic (silage tarps), clear plastic, and landscape fabric, are multi-functional, accessible tools that are increasingly popular on small farms. The use of opaque materials that block light is frequently called **"occultation"** while the use of clear tarps is called **"solarization."** We treat **"tarping"** as a general term to include both. Regardless of the material used, tarps are applied to the soil surface between crops and then removed prior to planting.

In cool climates like that of the Northeastern US, tarping has emerged as an important way to manage weeds, crop residue, soil moisture, and nutrients. Tarps can be versatile tools left in place for days to months at a time depending on context. They are commonly seen as 'placeholders,' covering soils to keep them weed-free and to retain moisture and nutrients until planting time. Many farmers use tarps to reduce the intensity of tillage or the number of tillage passes, while other farmers have moved to rotational no-till or even continuous no-till with tarps. Tarps have also been deployed as a way to transition new fields into production.

Farms using tarps are generally small (<5 acres) and employ organic practices, however, the reasons farmers use tarps are diverse. A recent survey of farmers in the Northeast (Rangarajan 2019 – see full Guide for list of works cited) showed that there are many different goals with tarping.

Despite the advantages of using tarps, there are tradeoffs to this practice and many unknowns. Farmers cite the logistics associated with handling tarps, including moving, securing, and storing them, as especially challenging. Because of these challenges, tarping is currently scale-limited. Tarping is a powerful weed management tool, but some weed species can become problematic when tarping is deployed without additional or alternative weed management techniques. Occupying valuable field space during the growing season with a tarp on land that would otherwise be planted to cash or cover crops represents an opportunity cost, and the benefits of tarping must outweigh the time required to implement the practice effectively. While tarps are reusable, they are made of plastic; manufacturing, disposal, and plastic contamination during their use are concerns.

[The full guide includes sections on types of tarps, logistics and management, specific tarping practices, concerns about plastic, and farmer case studies. The individual practice sections and farmer case studies serve as standalone resources. The section below on stale seedbedding is one of the tarping practice sections and is timely for growers considering tarping to create stale seedbeds this spring.]

"STALE SEEDBEDDING" WITH TILLAGE AND TARPS

Introduction

Stale seedbedding is a practice that encourages the germination of weed seeds, then kills emerged weeds before crop planting in order to minimize weed competition with the crop. The practice reduces in-season weed competition and can also deplete the weed seed bank, leading to reduced weed pressure in subsequent seasons (Gallandt, 2006). Tarps can be used for enhanced stale seedbedding.

Typically, stale seedbedding is done over a period of several weeks in the spring or early summer. Fields are prepared for planting with primary and secondary tillage, and raised beds may be made before applying this practice. These early-season soil disturbances help stimulate a "flush" of weed seeds to germinate. In traditional stale seedbedding, emerged white thread or cotyledon-stage weeds are killed with flaming, cultivation, or herbicide. When tarps are used for stale seedbedding, they are applied soon after field preparation, and kept in place for two or more weeks to allow time for weed seeds to germinate and be killed (Marenco and Lustosa, 2000).

Both occultation and solarization can enhance the flush of weeds by altering the soil's thermal and temperature regime. Emerged weeds are killed either from the absence of light (occultation) or extreme heat (solarization). Because it targets the seed bank, stale seedbedding is typically more effective for annual weeds than perennials. After tarp removal, crops should be seeded or transplanted into the prepared field with little additional soil disturbance – and certainly without further deep tillage or heavy cultivation – since disturbing soil can bring more deeply buried weed seeds to the soil surface, reducing the in-season benefit of the practice.

Farmers and researchers in the Northeast have had success with occultation and solarization for stale seedbedding in both fields and hoophouses (Birthisel et al., 2019; Fortier and Bilodeau, 2014). A key benefit to this practice is reducing the number of hand weeding, cultivation, or flaming passes needed by at least one. This results in less field traffic and fuel use. Under good conditions, solarizing can also create a better (less weedy) stale seedbed than is possible with other stale seedbedding techniques, potentially saving time and money on cultivation and hand weeding throughout the growing season while retaining valuable nitrate in the soil (Birthisel and Gallandt, 2019).

Logistics

Stale seedbedding with tarps can occur anytime during the growing season, especially in hoophouses. When applied in open fields, it is most commonly done in the springtime. For solarization, effectiveness is greatest near the summer solstice when solar energy gain is at a maximum.

Two weeks is a minimum time frame needed to establish a stale seedbed with tarping. This is based on the time required for many weed seeds to germinate and subsequently be killed. Farmer experience suggests that shorter treatment times may be effective in some circumstances. Research conducted in Maine found that four-six weeks does not typically lead to greater weed suppression than two (Birthisel and Gallandt, 2019).

Amendments that need to be incorporated into soils should be applied before tarping, so that field operations that could unearth buried weed seeds are not needed after tarp removal. Incorporating organic amendments before tarping may also improve the effectiveness of this practice by increasing microbial activity and microbial seed decay.

There are key tradeoffs when considering occultation vs. solarization for stale seedbedding. Solarization is a higher-risk, higher-reward scenario. Under ideal conditions and when correctly applied (i.e. when plastic is applied over moist soils with edges tightly secured) and the weather is hot and sunny, solarization results in higher soil temperatures, more weed seed bank depletion, and better subsequent weed control than occultation (Birthisel et al., 2018). However, because light can penetrate clear plastic tarps, solarization is more likely to 'fail' if conditions are not ideal, calling for subsequent occultation, tillage, or other practice to control weeds. Occultation is by comparison a lower-risk, lower-reward strategy: it is unlikely to fail in ways that cause a 'mess' that must be cleaned up through subsequent flaming or cultivation, but maximum effectiveness for depleting the seed bank is lower.

Research and experience in the Northeast have shown that solarization is a higher risk, higher reward method for stale seedbedding, while occultation is slightly less effective but also less likely to fail and cause a weedy mess that must be cleaned up through subsequent flaming or cultivation. Photo: L. Kenefic

Effects and outcomes from stale seedbedding with tarps

Stale seedbedding with tarps has proven effective at reducing weed density across a range of summer annual weeds including hairy galinsoga (*Galinsoga quadriradiata Cav.)*, redroot pigweed (*Amaranthus retroflexus L.)*, lambsquarters (*Chenopodium album L.)*, and crabgrass species (*Digitaria* spp.). Solarization decreased

subsequent weed density by 78% in Maine in comparison to a stale seedbed created with flaming, demonstrating that this application can be very effective when correctly applied.

Data from experiments in Maine suggest that solarization may indeed thermally kill some weed seeds at shallow soil depths. However, not all species are susceptible – neither solarization nor occultation have proven reliably effective against purslane in our region. This application of tarping also has minimal utility for controlling perennial weeds.

The substantial weed control achieved through stale seedbedding with tarps can contribute to improved yields. For example, a study in Brazil found that a stale seedbed created with 3 weeks of solarization decreased weed pressure and doubled carrot yield as compared with untreated controls (Marenco and Lustosa, 2000). Yield impacts are likely also a result of increased nutrient availability. As with other tarping applications, available nitrogen accumulates in the soil during stale seedbed periods and can be significantly higher under tarps compared to bare soil controls (Birthisel et al., 2019). Tarps may improve yields for direct seeded crops, especially in dry periods, by leaving a firm, moist seedbed that can lead to more favorable germination; on the other hand, added compaction can be a challenge for root crop development, depending on soil conditions.

Soil biological activity and abundance of beneficial soil microbes can be somewhat reduced during and for a period of days to weeks after tarping for stale seedbed establishment, with greater impacts seen for solarization than occultation. It is likely that reduced weed pressure contributes to this, as beneficial rhizosphere-associated bacteria may be less abundant where there are fewer plant (weed) roots with which to associate. Dead invertebrates including carabid beetles under tarps at the end of a stale seedbed period have been observed, and more research to evaluate the impact of tarping on these organisms would be beneficial.

Lettuce at planting in a conventional tillage system (left) and a continuous no-till system using tarps (right) at the Cornell Thompson Vegetable Research Farm in Freeville, NY. Repeated tillage events were used in spring to prepare tilled beds for planting while tarps were applied for several weeks, removed, and beds transplanted without soil disturbance. Photo: R. Maher

Drawbacks

Key considerations when stale seedbedding with tarps include the time, or opportunity cost, and labor required. When creating a stale seedbed using flaming, it is common practice to plant slow-germinating direct-seeded crops like carrots during the waiting period, and flame directly before crop emergence; with tarps, this is not possible. Another drawback is the time and effort required for tarp application – particularly for solarization, which requires tighter edge securement than occultation. Because stale seedbed preparation using tarps can be both time and labor-intensive, reserving this practice for high-value crops, particularly those that are slow-growing, highly susceptible to weed competition, or for which weeds are likely to interfere with harvest and cleaning (e.g., salad mix) is advisable.

Several drawbacks to the use of solarizing are worth reiterating. If temperatures under the tarp are sub-lethal, it can actually create a 'greenhouse' that encourages weed growth. This is likely to occur if plastic edges are not tightly secured, and when the practice is applied too late in the season and there is insufficient sunlight to achieve killing temperatures. Solarizing can also fail in low-lying portions of fields where water pools, creating a cool microclimate. Finally, not all species are susceptible to stale seedbedding with tarps; purslane germination even appeared to be stimulated by solarization (Birthisel and Gallandt, 2019). By contrast, black tarps may fail to result in substantial seed bank depletion if applied under suboptimal conditions, but are unlikely to fail so abjectly.

A cautionary tale - purslane seedlings successfully established after stale seedbedding with clear plastic during the summer in Maine. Photo: S. Birthisel

TAKE-HOMES FOR PRACTICAL NUTRIENT MANAGEMENT PLANNING

Managing soil fertility is often overwhelming and expensive for farmers. This year especially, lots of growers are concerned about high fertilizer prices and are wondering if they *really need* to put down full rates of fertilizer this spring. The following are some take-home messages from a series of nutrient management workshops held by Becky Maden and Laura Johnson of UVM Extension in March 2020. We hope these messages will prevent you from getting bogged-down by stacks of soil tests, in-depth fertility recommendations, and sky-high fertilizer prices.

In addition to the concepts discussed in this article, you can consider saving on fertilizer costs in crops grown on mulched beds by applying fertilizer only to the bed tops. Here are two methods for calculating these fertilizer needs: the Mulched Acres model, and the Linear Bed Feet model.

Pre-sidedress nitrate tests (PSNTs) are useful tools for dialing in your nitrogen rates every year, but especially this year if you want to try splitting fertilizer applications or applying less than you usually do. PSNTs measure the amount of plant-available N in the soil at the time of sampling. If PSNT levels are above 30ppm, generally, adding more N will not result in a yield increase. If you split your fertilizer applications this year (put down some at planting and plan to sidedress later), or if you want to try a reduced fertilizer rate, you can take PSNTs to inform your need for sidedressing and time those applications. PSNTs are also a great way to make sure you're not over-applying expensive N throughout the season—if a PSNT taken at the end of the season shows high N levels, you can consider lowering your fertilizer rates for next year. If you are relying primarily on organic forms of N (e.g. from compost, cover crops, soil organic matter, or organic soil amendments), this N is released slowly across many seasons. PSNTs taken monthly can help you evaluate whether this N is becoming available when your crops need it, or if you need to adjust.

Address the low-hanging fruit first: pH and macronutrients.

pH. Optimal pH for most vegetable crops is 6.5-6.8. Nutrients are most available at a neutral pH (7) and start to become unavailable as soil becomes more acidic. At a pH of 5.5, only 77% of N, 48% of P, and 77% of K in the soil is available to plants. Lime your fields to get your pH closer to 7 before you spend lots of money on fertilizers.

Macronutrients. Focus on reaching optimal levels of N, P, and K before addressing micronutrient concerns. Micronutrients are present in such small quantities in soils that they are hard to detect precisely with soil testing methods. Instead of trying to increase your soil zinc from 0.8 to 1.0 ppm, keep an eye out for nutrient deficiencies throughout the season and submit a tissue sample (the UMass Soil Lab is still not accepting tissue samples so we recommend using the UMaine Soil Lab) if you suspect a specific micronutrient deficiency.

Base cation saturation ratios: The model of soil fertility that all state university soil labs use is based on the proven concept that nutrient levels can be defined for all crop nutrients and below those levels, you will see a yield response in your crop if you add more of that nutrient. This is known as the "sufficiency level of available nutrients" model. There are some private soil labs that use the "base cation saturation" (BCSR) model. The BCSR model focuses on fertilizing soils based on the ratios of calcium, magnesium, and potassium in the soil, with the goal of achieving "ideal" ratios that will result in a "balanced" soil and maximum crop quality and quantity. This idea of ideal ratios was first proposed in the late 1800s but became popular in the 1970s after it was publicized by the soil scientist William Albrecht. However, the BCSR concept has since been disproved and it has been shown that maximum yields of many crops can be achieved across wide ranges of Ca:Mg and K:Mg ratios, if pH is maintained in an optimum range and sufficient macronutrients are supplied. While Mg and K deficiencies can certainly occur, it is much easier to address those deficiencies once the low-hanging fruit (pH and macronutrients) have been addressed. See the "Resources" list at the end of this article for more information about BCSR.

Prioritize problem fields and/or high-value crops. While we should strive to achieve the recommended fertility for every crop every year, it is not always realistic or even necessary. Crops respond to added nutrients logarithmically (Figure 1, right), meaning the initial response to added fertility is huge but there is a point of diminishing return, where adding more fertilizer leads to only small gains in growth or yield. Fertilizer is expensive! So spend your time and money wisely and get "close enough." Work on dialing in nutrients for fields where you see nutrient problems regularly and for high-value crops where you can't afford to get less-than-optimum yields. For other crops, you may be happy enough getting less-than-optimum yields and saving money on the fertilizer needed to get that last 5% yield.

Don't obsess over soil organic matter—work within the range of your soil type. Soil organic matter (SOM) includes living (e.g. insects, bacteria, fungi), dead (e.g. dead plants, insects, bacteria, fungi), and very dead (aka humus) material in soil. Organic matter is generally increased by incorporating cover crops or applying organic amendments like manure and compost, most of which have high phosphorous levels relative to crop need. Generally, 2-3% SOM is considered low, and 4-6% is considered good. *But* it's nearly impossible to maintain SOM above 3% in a sandy soil, and if you're adding enough compost that your SOM is increasing above 3%, your phosphorous levels are very likely well above optimum. If you have sandy soils, aim to maintain your SOM instead of increasing it. Across all soil types, look at the trend of your SOM and don't obsess over the value alone. If you're increasing your SOM without applying excessive phosphorous, great! If you're maintaining your SOM, great! If your SOM is decreasing, consider making a change.

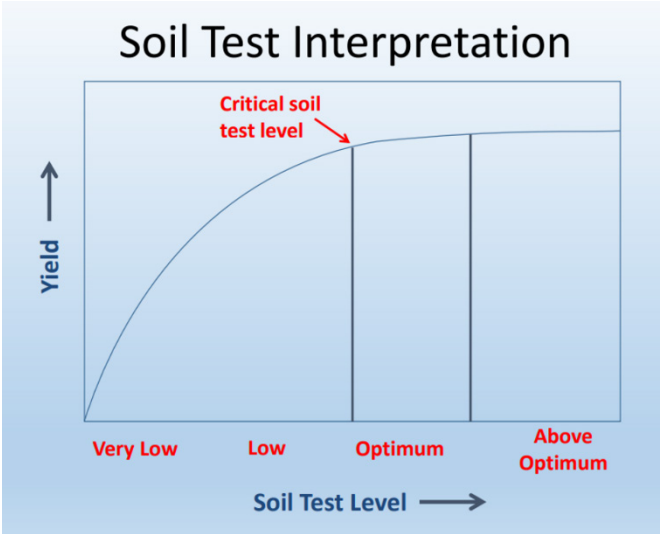


Figure 1. Crop yield response to soil nutrient levels. If a soil contains no nutrients, adding some nutrients will result in a large increase in yield. As soil nutrient levels approach optimum, each incremental addition of nutrients has less and less of an effect on crop yield. Figure: UVM Extension

Know your phosphorous levels and your environmental risk level before adding organic amendments. Phosphorous is an essential plant nutrient but can become an environmental pollutant if large quantities enter water sources. This is mainly an issue with large-scale growers who use manure or compost or who are growing on fields that historically had lots of manure put down. When P levels are high, there are no corrective actions except avoiding adding more phosphorous. Most organic amendments—composts and manures—are high in P. Cover crops are great ways to add organic matter without adding P. In high tunnels, where cover cropping is difficult, peat moss and coconut coir are two options for adding organic matter without adding extra P.

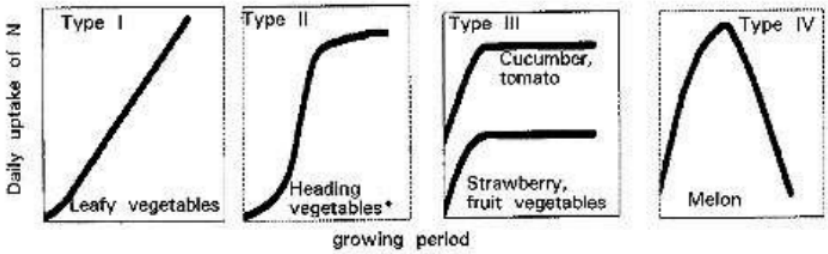


Figure 2. Uptake of nitrogen over the growing period of various crops. Figure: Redrawn from Kato 2000.

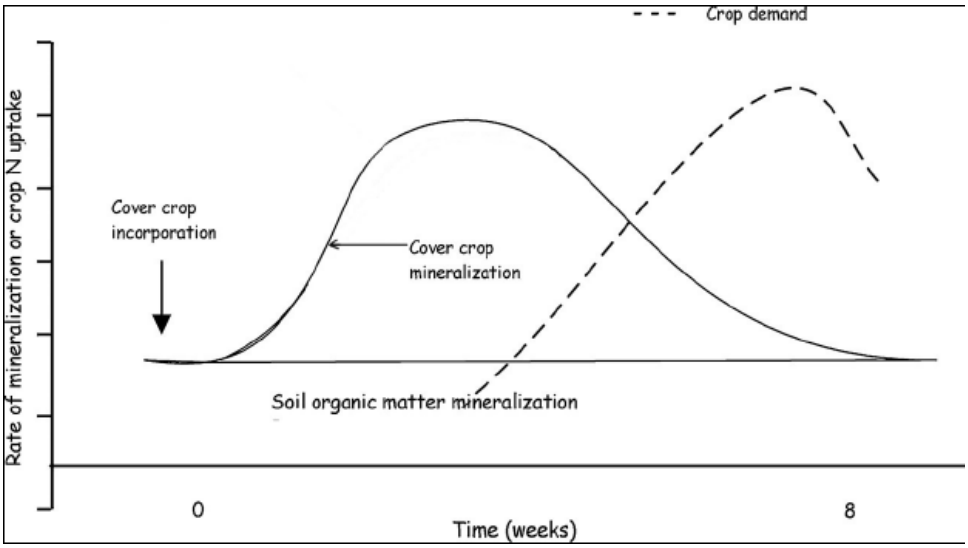


Figure 3. Timing of nitrogen (N) mineralization from soil organic matter, cover crop residues, and organic fertilizer in relation to crop N uptake (from Gaskell et al., 2006).

Optimal phosphorous ranges from a Modified Morgan soil test is 4-7ppm; above that, your phosphorous levels will be reported as "excessive". That means a P at 8ppm will look the same on the soil test report as one at 300ppm, even though 300ppm is much worse than 8ppm. Generally speaking, P levels above 50 ppm are alarming. We've heard some farmers say that excess P is not a big deal as long as your field is not next to a waterway—not so! There is a growing awareness that long-term over-application of manure and chemical fertilizer contributes to phosphorus movement into the groundwater system, resulting in a significant groundwater source of phosphorus to streams and lakes, as well as potential contamination of the groundwater resources. Further, excessive P can tie up zinc leading to deficiencies.

Updated high tunnel fertility and production recommendations. Research and surveying from several New England states in 2018 resulted in new high tunnel fertility recommendations, that are now included in the Greenhouse & High Tunnel Tomatoes section of the New England Vegetable Management Guide. The research is also summarized in this 2018 High Tunnel Survey Report. The take-home message from this research is that high tunnel tomatoes should be fertilized based on the potential yield of the production system: a heated tunnel of indeterminate, hybrid, disease-resistant, grafted tomatoes that are closely spaced and heavily pruned has the *potential* to produce much higher yields than an unheated tunnel of determinate heirloom tomatoes that will be harvested 3 times before they go down to leaf mold. The first scenario requires much more nutrients than the second. The Guide and fact sheet list nutrient recommendations for low, medium, good, and high yields, all of which refer to the *potential* yield of your high tunnel tomato production system.

An important part of these new recommendations **Salts can build up in the top two inches of high tunnel soil.** Salts are wicked to the soil surface through evaporation and are not flushed back down because there's no rain. These salts are nutrients, so you don't want to remove them, but they can cause plant damage in high concentrations so take measures to mix or flush them deeper into the soil. Mix the soil by rototilling or plowing to a >6" depth and/or leave the tunnel plastic off for the winter every time you change it, to flush the salts back down.

In conclusion, when you get all 35 of your soil tests back and don't know where to start remember that you just need to get close enough, start with the low-hanging fruit, and feel free to contact any of us for help making a plan or going through some of the calculations.

Additional Resources:

- Becky Maden created a fertilizer calculator where you can enter nutrient levels, soil pH, and organic matter levels from a soil test, as well as cover crop information, and the spreadsheet will walk you through how much of a given amendment you should be applying to your field.
- Base Cation Saturation Ratio System, *Building Soils for Better Crops*. Magdoff, F., and van Es, H.
- A Review of the Use of the Basic Cation Saturation Ratio and the "Ideal" Soil. Kopittke, P., M., and Menzies, N. W.
- Phosphorous and Groundwater: Establishing Links Between Agricultural Use and Transport to Streams. Domagalski, J. L., and Johnson, H.
- The New England Vegetable Management Guide covers many of these topics:
- See the Plant Nutrients section for more information on both macro- and micronutrients
- See the Fundamentals of Soil Health and Fertility section for more information on soil organic matter and pH
- See the Fertilizer and Soil Amendments section for information on fertilizers as well as manure and compost.

--Written by G. Higgins and S. Scheufele

SUNFLOWER POLLEN AND BEE HEALTH: RESEARCH FROM THE ADLER LAB AT UMASS AMHERST

In the February 2022 issue of Veg Notes, we provided an update on bee health. We described how native bee populations are declining due to habitat loss, disease, pesticides, and climate change. And we pointed out that the most effective way to help bees is to establish habitat; that is, maintain flowering plants for bees to eat and leave undisturbed areas for them to nest.

But which flowers are best to plant? We know that diversity is important; as a rule of thumb, that means floral mixes should include at least three plants that bloom each season. However, there is still much that we don't know about how different flowers affect bee health. Pollen and nectar vary widely among plant species – in terms of nutritional composition, chemistry, and morphology – and this variation affects bees and bee pathogens in complex ways. The impact of floral diet on bee health is an active area of research globally, and here in Massachusetts.

In this article, we will describe some novel research on bee habitat that is happening here at UMass Amherst. Dr. Lynn Adler and her lab study how floral diets affect bee diseases. In 2015, they found that common eastern bumble bees (*Bombus impatiens*) fed sunflower pollen had lower levels of a ubiquitous gut parasite (*Crithidia bombi*). They've since

conducted numerous experiments to learn how and why sunflower pollen impacts bumble bee disease. Their goal is to understand the value of sunflower and related plants as part of a diverse floral mix. (You can read more about this research in this fact sheet).

METHODS

The Adler Lab uses the model system of the common eastern bumble bee and their ubiquitous gut parasite *Crithidia* to answer questions about how pollen chemistry and shape affect bee disease.

The common eastern bumble bee *(Bombus impatiens)* is native to many parts of Eastern North America. Unlike most wild bees, bumble bees live in social colonies. Each colony is founded in the spring by a queen bee. She searches for a ground cavity, such as an abandoned rodent burrow, in which to establish her nest. She then lays eggs and provisions them with pollen and nectar. The colony grows to several hundred individuals over the summer. Most of the bees are female workers. Towards the end of the summer, the queen starts producing males and reproductive females (daughter queens) that leave the nest and mate. In the winter, the colony dies, and only the newly mated queens overwinter underground. Unlike many native bees, the common eastern bumble bee is not in decline. In fact, populations have been increasing. However, it is an ideal organism to study because it is reared commercially for greenhouse pollination so can be purchased easily and maintained indoors. Colonies can also be reared in the lab from wild-caught bees. In addition, this bee is important because it is very abundant and likely transmits diseases to other bees.

The pathogen *Crithidia* *(Crithidia bombi)* **is** a gut parasite of bumble bees. *Crithidia* is a protozoan pathogen that lives in bee intestines and is transmitted through feces in the colony or on flowers. Studies find that it is ubiquitous among bumble bees in Massachusetts. It reduces bumble bee longevity, learning, foraging and queen hibernation. It is useful to study because it is widespread and can be easily maintained in a lab.

Crithidia bombi
Photo: Boris Baer

The common sunflower (*Helianthus annuus*) is native to North America and its yield is improved by bee pollination. Sunflowers are cultivated worldwide for their oil; in 2018, there were over 1.2 million acres planted in the United States. Sunflower pollen is relatively low in protein, so bees fed exclusively sunflower have smaller larvae and shortened lifespans. However, when bees eat 50% sunflower pollen mixed with pollen from other flowers, they live as long as bees fed non-sunflower pollen. Sunflower pollen is notable because it has a spiky exterior, like pollen from many plants in the same family (*Asteraceae*).

For all lab experiments, bumble bees were exposed to *Crithidia*, fed different pollen diets, and then dissected to assess *Crithidia* levels. Figure 1 (below) shows the experimental method for Giacomini et al. 2018 (described in "1. Main Finding"). Variations to this method are indicated for each result.

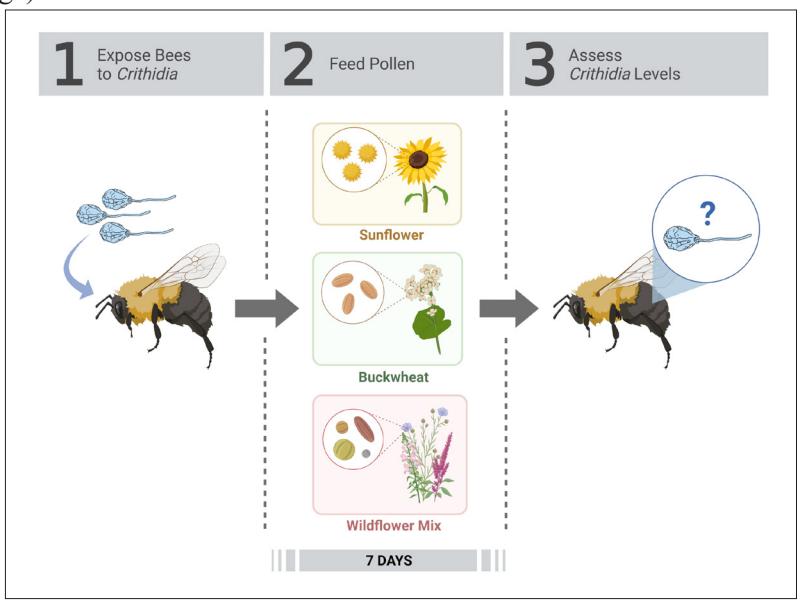


Figure 1. Experimental method for Giacomini et al. 2018

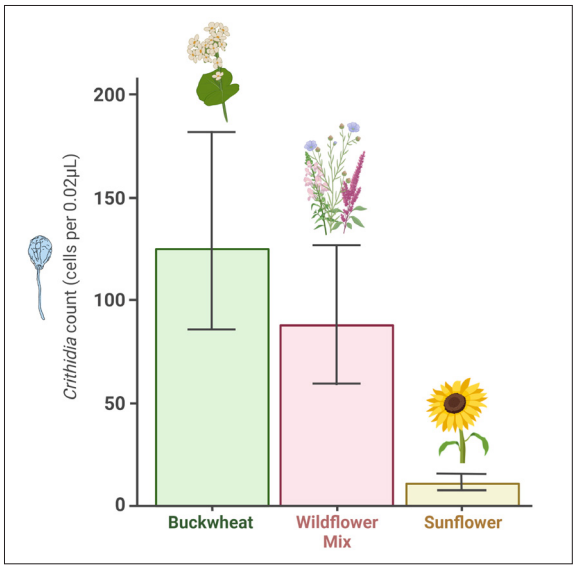


Figure 2. Crithidia *level by pollen diet. Bees fed a sunflower pollen diet had significantly lower* Crithidia *counts than bees fed buckwheat or a wildflower mix. Adapted from Giacomini et al. 2018.*

RESULTS

1. Main finding

Sunflower pollen dramatically reduced *Crithidia bombi* in both wild and commercial *Bombus impatiens*. After exposing bees to *Crithidia* and feeding them different pollen diets (see Figure 1), Adler Lab researchers consistently found that bees fed sunflower pollen had dramatically lower levels of *Crithidia* than bees fed buckwheat or wildflower pollen (Figure 2, previous page). Because buckwheat pollen, like sunflower pollen, is low in protein, the researchers also concluded that sunflower's low protein is not the reason it reduced *Crithidia*. Read the full paper here.

2. Do we see this effect outside the lab?

Yes! Bumble bees on farms with more sunflower had less *Crithidia*. In 2015, researchers gathered wild bumble bees from farms around the Pioneer Valley. They measured the area of sunflowers grown at each farm and assessed the bees' *Crithidia* infection. They found that bees caught on farms with more sunflower had lower infection. Read the full paper here. In 2019, researchers placed commercial bumble bee colonies on Pioneer Valley farms with varying amounts of sunflower. At the end of the experiment, they assessed colony growth and *Crithidia* infection. They found that colonies placed on farms with more sunflowers had less *Crithidia* and reproduced more than colonies on farms with fewer sunflowers. Malfi et al., in prep.

3. How broad is this effect?

Many different types of sunflower pollen reduced *Crithidia* in *B. impatiens*, including goldenrod, which is in the sunflower family but is not that closely related. Researchers exposed bees to *Crithidia* and then fed them nine varieties of commercial sunflower, four varieties of wild sunflower and two species of goldenrod, a distant sunflower relative. They found that all sunflower or goldenrod pollen reduced *Crithidia* 20-40-fold when compared to buckwheat pollen (and most reduced *Crithidia* compared to wildflower pollen) (Figure 3). This is important because it implies that sunflower's medicinal qualities may extend to other members of the sunflower family, a diverse plant group found all over the world. Read the full paper here.

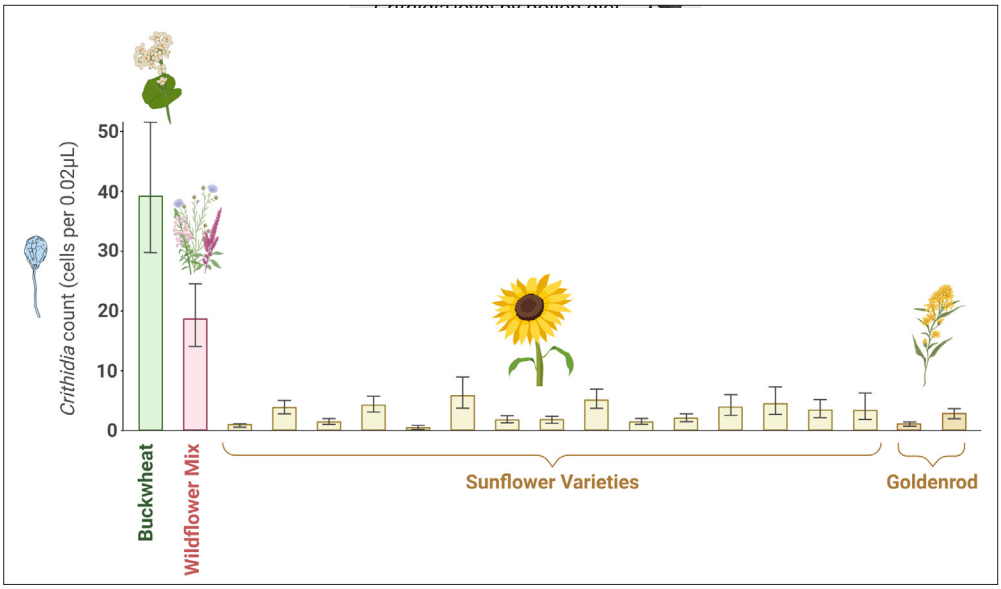


Figure 3. Crithidia level by pollen diet. Pollen from multiple sunflower varieties and goldenrod species reduced Crithidia *levels relative to buckwheat pollen and a wildflower pollen mix. Adapted from LoCascio et al. 2019.*

Sunflower pollen reduced *Crithidia* in queens and workers, but not males. Researchers tested whether sunflower affects bee castes differently. They found that it reduced *Crithidia* in females (queens and workers) but not males. The effect on queens is important because daughter queens that emerge in the fall establish new colonies the following spring. Males had relatively low *Crithidia* levels regardless of diet, which may be because they consume very little pollen, and *Crithidia* is low when bees don't eat pollen. Read the full paper here.

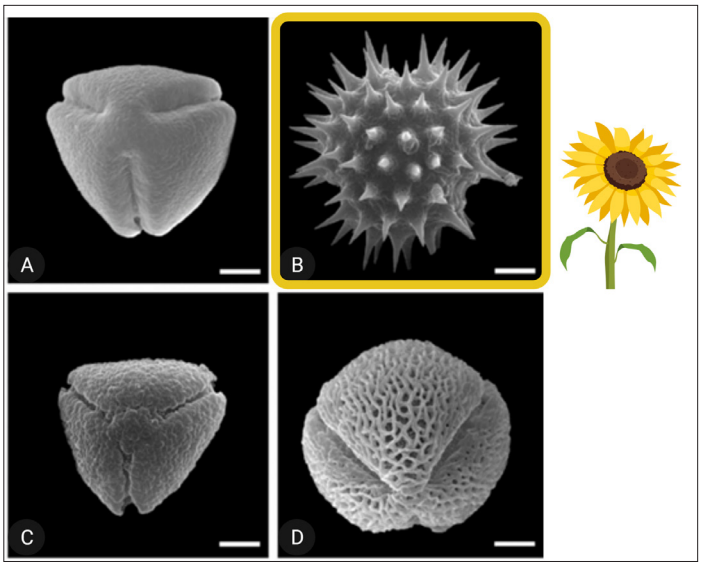
Sunflower pollen did not reduce *Crithidia* as dramatically in other bumble bee species. Researchers tested whether sunflower pollen reduced *Crithidia* infections in three other wild bumble bee species: *Bombus griseocollis, Bombus bimaculatus*, and *Bombus vagans*. They found that it slightly reduced *Crithidia* infection in *B. bimaculatus* and *B. vagans* and did not reduce infection in *B. griseocollis*. *B. impatiens, B. bimaculatus* and *B. vagans* are more closely related to each other than they are to *B. griseocollis*. Read the full paper here.

A 50% sunflower pollen diet reduced *Crithidia* infections. Dr. Adler's collaborator Becky Irwin and her team at NC State University tested whether sunflower pollen still reduced *Crithidia* when combined with wildflower pollen. This

is important because sunflower pollen is low in protein, and bees cannot eat exclusively sunflower pollen for long periods of time. The team fed individual bees either 100% sunflower pollen, 50% sunflower pollen, 25% sunflower pollen, or 100% wildflower pollen. They found that even a 50% sunflower diet reduced *Crithidia* infections. Read the full paper here.

4. Why does sunflower reduce *Crithidia*?

Sunflower may reduce Crithidia because of its spiky outer shell. Researchers in the lab isolated different chemical components of sunflower pollen (nine fatty acids and two defensive compounds) and fed them individually to bumble bees. They found that none of the compounds individually reduced *Crithidia*. Read the full paper here. Then they separated the spiky shell from the other pollen components and fed it to bees. They found that the hollow spiky shell alone reduced *Crithidia* as much as whole sunflower pollen, pointing to a physical mechanism. This may explain why pollen from other plants in the sunflower family (which also have spiky pollen), reduce *Crithidia*. Figueroa et al., in prep.



SEM photographs of some pollen types. Sunflower pollen is in the top right corner; notice how spiky it is. Pollen key: A. Sarcomphalus mistol. *B.* Helianthus annuus. *C.* Eugenia uniflora. *D.* Schinopsis balansae. *Scale bars – 5 µm.*
Adapted from Salgado et al. 2017.

TAKE-AWAY

- Sunflower (and related plants like goldenrod) may reduce a pervasive gut parasite in the common eastern bumble bee. This species is not in decline, but it is quite common, so may spread diseases to other species.
- However, sunflower is relatively low in protein, so is best for bees as part of a diverse wildflower planting.
- So…should you plant sunflowers to help bees? YES! But don't forget to plant other flowers as well, to provide a diverse diet for your local pollinators. For more info on planting for bees, click here.

NEXT STEPS

- The lab is exploring how commercially grown cut flowers in the sunflower family (*Asteraceae*) affect bumble bee health. This research could help us understand the impact of cut flower production on bees, and whether cut flowers could be a way to improve habitat for bees in agricultural areas.
- The lab is also assessing the value of pollen from different native plants, which could be used to create pollinator habitat in conservation areas.
- They are also collaborating with ecologists and molecular biologists to understand how pollen affects *Crithidia* at a molecular level, how plants affect disease transmission, and what plants are visited most by bees, in order to model how plant communities affect bee health.

--Written by Hannah Whitehead, UMass Extension Vegetable Program

News

MDAR Seeking Input from Socially Disadvantaged Farmers

MDAR is currently in the process of developing an application to submit to USDA to implement the Local Food Purchase Assistance Cooperative Agreement Program (LFPA) for Massachusetts. Applications are due by May 6th, 2022 to USDA, and should our application be successful, it is anticipated that the state will receive $7.5M. We want to thank the participants who attended the listening session on February 3rd. Your feedback will help to develop a strong proposal to USDA and build an equitable and impactful program.

A key goal of the LFPA is to build supplier relationships with local and regional farmers and ranchers, socially disadvantaged farmers and ranchers, and underserved communities. To that end, MDAR is seeking to establish a database

of Socially Disadvantaged farmers to ensure that self-identified farmers are kept informed of the process. The more individuals we can reach, the more effective our work will be in the future.

Please complete this form to self-identify as a Socially Disadvantaged farmer or producer. If you have any questions about how your information will be used, please contact Rebecca.Davidson@Mass.gov. Please disseminate this form through your networks.

Para completar este formulario en español, seleccione "Spanish" en la parte superior de la página.

Para completar este formulário em português, selecione "Portuguese" no topo da página.

If there are other languages that need translation, you can use the Google Translate bar, which is at the top of any Mass.gov webpage.

Application Period Open for MDAR's Viability Grant Programs

The due date for all these three applications is Tuesday, April 26, 2022.

- **Farm Viability Enhancement Program (FVEP) –** for established farms. This program provides business planning and technical assistance to develop or update a business plan for established commercial farms that own and operate unrestricted farmland. In return for a short-term covenant to keep the land in agricultural use, operators may be eligible for grants to implement capital projects on the farm that have been identified in the business plan completed through the program. Grant levels range from $75,000 to $150,000, depending on the size of the farm and acreage protected, in return for a 10 or 15-year term covenant. Uses of funds will vary depending on the needs of the farm – examples include new or improved livestock barns or farm stores; purchasing delivery vehicles, tractors or haying equipment; constructing food processing or storage facilities.

  For more information and a FVEP application, go to: Farm Viability Enhancement Program or contact Melissa Adams at Melissa.L.Adams@mass.gov or 413-726-2001

- **APR Improvement Program (AIP)** – for APR farms. This program helps sustain active commercial farming on land that has already been protected through the state's Agricultural Preservation Restriction (APR) Program. AIP provides business planning and technical assistance to farmers selected to participate in the program and grants may be available on a reimbursement basis to implement identified improvements on the farm to increase productivity and profitability. Grant levels are up to $60,000; $90,000; or $120,000 depending on the size of the farm and acreage under APR, available on a cost reimbursement basis with a required 25% match contribution. AIP funds are used primarily for capital improvements to farm infrastructure, such as new or improved barns for equipment or hay storage or livestock housing, farm stores, processing facilities; or resource improvements for agricultural use, such as orchard renovations or fencing.

  For more information and an AIP application, go to: APR Improvement Program or contact Michael Parker at Michael.Parker@mass.gov or 857-895-0023

- **Matching Enterprise Grants for Agriculture (MEGA)** – for beginning farmers, who have been in business at least one (1) but no more than six (6) years who aspire to develop their farms into commercially viable operations. The program provides business planning and technical assistance, and grant funds of up to $10,000 on a one-to-one matching cash reimbursement basis. Funds may be used for equipment, infrastructure, or other capital improvements identified through the business planning process that will have a positive impact on the participating farm's viability. Common uses of MEGA grant funds include greenhouses, barn renovations, tractor implements, chicken coops, farmstands, and refrigerated delivery trucks.

  For more information and a MEGA application, go to: Matching Enterprise Grants for Agriculture or contact Jess Camp at Jessica.Camp@mass.gov or 617-823-0871.

Reminder: Chlorpyrifos Agricultural Tolerances Expired February 28, 2022

On August 18, 2021, the EPA announced that it would revoke all tolerances for chlorpyrifos, which establish the amount of a pesticide that is allowed on food. This revocation went into effect on February 28, 2022. **This means that currently, chlorpyrifos cannot be used on agricultural products; any product treated with chlorpyrifos will be considered adulterated and cannot be sold. Existing stocks of chlorpyrifos products cannot be used.** This decision was made after the EPA determined that the current aggregate exposures from use of chlopyrifos do not meet the legally required safety standard that there is a reasonable certainty that no harm will result from such exposures.

Chlorpyrifos products that were previously labeled for use in vegetable crops include Bolton, Cobalt, Hatchet, Lorsban, Match-Up, Nufos, Stallion, Vulcan, Warhawk, Whirlwind, and Yuma.

State Restriction of Pesticide Products Containing Neonicotinoids

The Massachusetts Pesticide Board Subcommittee ("Subcommittee") is the entity that registers pesticide products in Massachusetts. During a recent Subcommittee meeting, the Subcommittee determined that current uses of neonicotinoid pesticides used in outdoor non-structural uses or outdoor non-agricultural uses may pose unreasonable adverse effects to the environment as well as pollinators, when considering the economic, social, and environmental costs and benefits of their use in the Commonwealth. Therefore, the Subcommittee voted to modify the registration classification of pesticide products containing neonicotinoids that have outdoor non-structural uses or outdoor non-agricultural uses on the label **from general use to state restricted use**. These uses include, but are not limited to, uses on lawn and turf, trees and shrubs, ornamentals, and homeowner vegetable and flower gardens. **The reclassification shall be effective on July 1, 2022.**

This reclassification is going to affect a large number of products and it is important that pesticide applicators begin planning for the upcoming changes. Anyone using a product that is classified as State Restricted Use must have a Commercial/Private Certification or have a Commercial Applicator ("Core") License and be working under the Direct Supervision of someone with a Commercial/Private Certification License. The Department is providing this notice now so that companies can plan for the 2022 season.

We encourage you to visit this Frequently Asked Questions document for more information on this change, including which active ingredients are classified as neonicotinoids, what types of products will become restricted, and what to do with leftover product that has become restricted if you do not hold the proper license to apply the product.

Events

Preventative Control for Human Food Training

When: Tuesday-Thursday, May 10-12, 2022, 9am-2pm
Where: IALS Conference Center, UMass Amherst, 240 Thatcher Rd., Amherst, MA 01003
Registration: $600. Lodging is not included in the registration fee; see following link for more information. Click here to register.

The Current Good Manufacturing Practice, Hazard Analysis, and Risk-based Preventive Controls for Human Food FDA regulation is intended to ensure safe manufacturing/processing, packing and holding of food products for human consumption in the United States. The regulation requires that certain activities must be completed by a "preventive controls qualified individual" who has "successfully completed training in the development and application of risk-based preventive controls." This course developed by the FSPCA is the "standardized curriculum" recognized by FDA; successfully completing this course is one way to meet the requirements for a "preventive controls qualified individual."

To complete the course, a participant must be present for the entire workshop and actively participate in all of the presented exercises.

Questions? Contact Christina Wormald, cwormald@umass.edu, 413-545-2278.

Vegetable Notes. Genevieve Higgins, Lisa McKeag, Susan Scheufele, Hannah Whitehead co-editors. All photos in this publication are credited to the UMass Extension Vegetable Program unless otherwise noted.