UMass Extension

Vegetable Notes

For Vegetable Farmers in Massachusetts since 1975

Volume 29, Number 6 May 11, 2017

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CROP CONDITIONS

With the cool wet weather, crops and transplants are not doing much except for damping off; rather frustrating! However, spring seeded oats and peas are slowly beginning to carpet fallow areas and fields planned for fall crops. If it seems like spring temperatures are rising earlier, but fields are remaining wet, making it impossible to plow, well, that hunch is backed by data (Fig 1). While climate change is pushing the last spring frost earlier, it is also bringing increased spring precipitation. In response to this trend, some growers are experimenting with growing practices that don't require tillage: using tarps to kill cover and suppress weeds (Fig 2), using a roller crimper, or trying reduced tillage with a deep zone tiller.

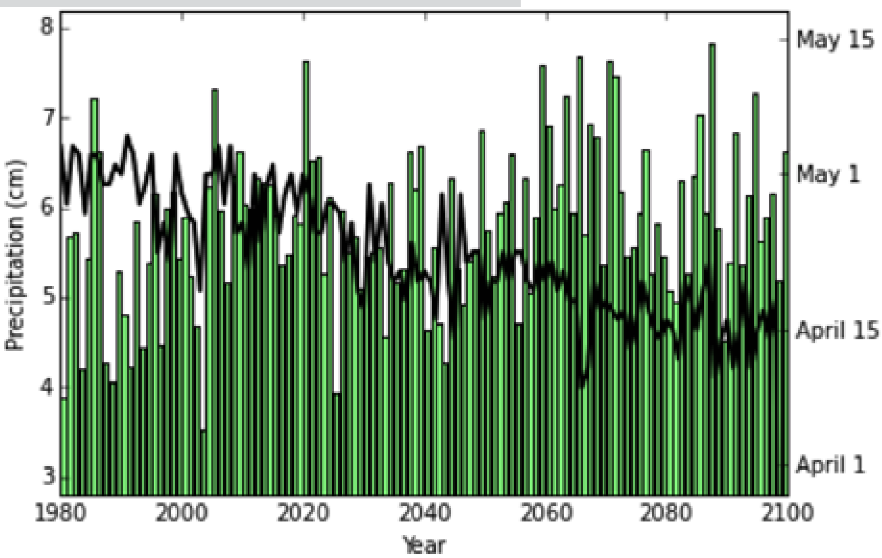

Fig 1. Trend in Northeastern U.S. for earlier last frost (black line) and trend in rainfall amounts in the 21 d prior to last frost (green bars) for the historical and projected period of 1980 – 2100. (Source: A. DeGaetano, Northeast Regional Climate Center and Cornell University, unpublished)

Despite the slow spring, retail shops opened on schedule, and sales of transplants, the cash cow this time of year, are at a crawl with customers waiting for warmer weather. Looking at recent trends though, more growers have switched to wholesale production in the Connecticut River Valley. According to a recent Community Involved in Sustaining Agriculture Report: "Total vegetable sales in the Pioneer Valley nearly doubled between 2002 and 2012, from roughly $24 million to about $46 million. During that same period, total direct sales for all farm products in the region only increased by about $5 million, indicating a significant increase in vegetable sales through wholesale channels."

Wherever your markets are, the same production issues will surely continue to plague you this year, so don't forget to use our diagnostic and soil lab services! Addresses and contact information are on the next page:

Fig 2. One organic grower in northern Franklin Co. is trialing 3 side-by-side bed preparation treatments this year in a September-seeded rye and vetch field to grow cucurbits: 1) traditional plow and disc, 2) Roller crimper with deep zone tillage 3) deep zone tillage followed by sillage tarping. This image shows the silage tarp in place with the farmer's daughter for scale. Note from Brookfield Farm (tarp supplier): A tarp larger than 32 x 100 ft and 5mil weight is too large and heavy to manage without multiple people. *Photo: T. Neukirch.*

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Cabbage maggot eggs found on Friday, May 5th on overwintered kale in Franklin Co. Photo: G. Higgins

Accumulated Growing Degree Days (F): 1/1/17 - 5/10/17 Values based on NEWA models: http://newa.cornell.edu

Location	GDD (base 40F)
Western MA	
Ashfield	434
South Deerfield	519
Pittsfield	447
Central MA	
Bolton	561
Northbridge	564
Phillipston	457
Eastern MA	
Ipswich	535
Waltham	609
Seekonk	669
Hollis, NH	532
Burlington, VT	485
Newport, RI	588
Castleton, NY	650

Pest Alerts

Allium:

Allium leafminer (ALM) has been confirmed in the New York Hudson Valley. Eggs and larvae have been found in overwintered scallions in Orange Co., and feeding damage has been found in Dutchess Co. Chives are the most attractive crop to ALM, so check them first, in addition to any alliums that have overwintered (including volunteers in cull piles). Strangely, adult ALM flies have not been appearing on sticky cards, so check your crops even if your sticky cards are clean. All chemistries approved for onion thrips work similarly for ALM, though no materials are specifically labeled. Mow down overwintered alliums.

Onion maggot feeding damage was reported in Essex Co., MA and Chittenden Co., VT, though the damage is likely from seed corn maggot. See Table 2 for comparison. Adult onion maggot flies have emerged in most locations across MA, according to the NEWA onion maggot forecasting model, but peak emergence of this pest is 735 GDD base 40°F, which is still about a week away in most locations around the state (Table 1).

Brassica:

Cabbage root maggot (CRM) was reported in Providence Co., RI on a small planting of cabbage and in Essex Co. MA, but again, this is likely seed corn maggot. Peak flight (50% emergence) of CRM is at 452 GDD base 40°F, which was May 1st in Franklin Co., MA. Egg hatch should be occurring now (7-10 days after laying), so expect to begin seeing damage this week if eggs were present. Pre-plant and transplant treatments are available in the New England Vegetable Management Guide. Adult emergence and flight may be monitored by following the NEWA cabbage maggot forecasting model or by using yellow sticky cards.

Flea beetle emerged and moved into fields earlier in April when the weather first warmed up, and has damaged 100% of a small turnip crop in Franklin Co., MA. Although the cool weather has slowed down their activity, second plantings of brassicas should be under row cover or treated at 20% infestation (1 flea beetle per plant) or 10% of plants with holes.

Multiple:

Seed corn maggot flies can emerge even under row cover from pupae that overwintered in organic matter applied in the fall. If you see maggots in brassica or allium transplants at this time, they could be seed corn maggot, as it is the earliest of the maggots to emerge! We have gotten reports of maggot damage in brassica and allium transplants in Essex Co., MA, Providence Co. RI, and Chittenden Co., VT – all likely seed corn maggot. Because of the confusion surrounding maggot infestations at this time, we developed a handy comparative chart (Table 2). Seed corn maggot was particularly abundant last year all across New England at this time. If possible, delay seeding into fields where problems occurred last year, since this pest has such a large host range. Fields fertilized with seed meals (ie. soybean, peanut) have also experienced problems with this pest in the past, because flies and maggots are attracted to these fertilizers for food. Peak flight occurred at 360 GDD base 40°F at our research farm in South Deerfield, and eggs hatched soon after (2-4 days after laying, compared with cabbage root maggot eggs, which take 7-10 days). These maggots will feed on transplants and seedlings for 2-3 weeks before pupating which means we may continue to see damage from them for another week. There may be 2-3 generations in New England, but the 1st generation larvae are the most damaging.

Western Flower Thrips damage on vegetable seedlings (particularly eggplant, pepper, and tomato) is being reported in many greenhouses at this time, including in our research greenhouses at UMass where plant material remains in the house year round, giving us no chance to sterilize the space. For organic growers, Azaguard and Pyganic provide some knock down effect but not total control. Avoid using these materials if you use biological controls since they are broad spectrum insecticides. Check out this *Orius* guardian plant system developed by Carol Glenister at IPM Labs and researchers at Cornell as a biocontrol strategy for thrips. Predatory mites (*Amblyseius cucumeris*) are also being used with positive results as biocontrols against thrips.

Thrips damage on an eggplant seedling: window paning in the cotyledon and curled tips. Photo: G. Higgins

Table 2. Maggot Comparative Table			
	Seed Corn	**Cabbage**	**Onion**
Host	40 different plants, large germinating seeds, seedlings (including allium and brassica!)	Brassicas	Alliums
First peak flight	360 GDD base 40°F	452 GDD base 40°F	735 GDD base 40°F
Adult	Small: ~ 3mm, 3 stripes on the thorax	Medium: ~5mm, 2 stripes on the thorax.	Large: ~6mm.
Eggs	Hatch in 2-4 days	Hatch in 7-10 days	Hatch in 2-5 days
Larvae (maggot)	Active for 3 wks	Active for 2-4 wks	Active for 2-3 wks
Pupae	In soil for 1-2 wks before next gen adults emerge (last gen pupae overwinter)	In soil for 2-3 wks before next gen adults emerge (last gen pupae overwinter)	In soil for 3-4 wks before next gen adults emerge (last gen pupae overwinter)
Notes	Short, 21-day lifecycle. 3 gen per year. Usually only spring gen is damaging.	Long, 60-day lifecycle. 4 gen per year. Spring and Fall gen most damaging.	Medium, 30-day lifecycle. 3 gen per year. Usually only spring gen is damaging.

FLEA BEETLE MANAGEMENT

Flea beetles have emerged from their overwintering homes in the shrubby or wooded areas surrounding fields and begun to feed on the first spring brassica plantings. Controlling flea beetles can seem like a losing battle, but we have seen real success on farms that have taken an integrated approach to management. The most important steps to reducing the population size and damage caused by flea beetles seem to be breaking the cycle (rotating spring crops as far away as possible from overwintering sites near last years' fall crop), and controlling early season outbreaks using something like a trap crop or a "push-pull" approach to prevent the problem from spiraling out of control within the season or from building up to unmanageable levels over the years.

Life Cycle. The crucifer flea beetle (*Phyllotreta cruciferae*) is uniformly black and shiny (top left), while the striped flea beetle (*Phyllotreta striolata*) has two yellow stripes on its back (bottom left). Both are about 2 mm in length and hop away when disturbed. These flea beetles only feed on brassica crops; those found on corn or solanaceous crops are different species. Though they prefer the tender leaves of *Brassica rapa* & *B. juncea* crops such as arugula, tatsoi, mizuna, bak choi, and mustard, they will also feed on the more waxy *Brassica oleracea* crops such as broccoli, cabbage, kale and collards. Their feeding damage—small, round holes on leaves or leaf margins, which can coalesce to form large holes as leaves mature—can destroy or delay maturity in seedlings and reduce yield and marketability of older plants. The adults in fields now will lay their eggs in the soil. Larvae will feed on the root hairs of brassica crops, pupate underground, and emerge as adults in late July to feed on fall brassicas before moving outside of the field for the winter.

Management: Break the cycle! Plant spring crops far from fields where fall brassicas were grown, and where flea beetles will overwinter. When overwintering beetles emerge, if they can't find a host plant they will not survive and reproduce and you will reduce the population of flea beetles on your farm. You can also starve the overwintering beetles by delaying planting until July. This may not easily fit your markets, but it does work. With no food or place to lay eggs, the overwintered adults leave the area, instead of reproducing and emerging in time for midsummer dining. It may take 2-3 years to bring populations down. Control weeds at the same time. The best protection for a spring brassica planting is isolating the crop from where the beetles would have overwintered, near last years' fall crop. Finally, separate your fall crop from the spring crop, since second generation flea beetles will emerge at the same time that fall cole crops will be at their most vulnerable. These second generation adults are also the beetles that overwinter, so next spring, plan to use a field distant from previous late-season brassica fields. After harvests, till crop residue immediately to uproot and kill underground larval populations.

Row covers. Floating row cover provides the most effective protection from flea beetles, especially in spring and early summer. It is expensive in both materials and time, but it works. It is critical to seal the edges immediately after seeding, because brassica seeds germinate quickly and beetles rapidly find the cotyledons. Flea beetles can fit through small openings – not to mention the large holes and tears that often develop in row cover over time. Edges of the cover must be sealed on all sides using soil, black plastic bags filled with soil, or some other method. Fortunately hoops are not needed on brassica crops, but management is still time-consuming because the cover has to be removed for cultivation. Replace it as soon as possible to avoid letting beetles in.

Other insect barriers, such as Proteknet, Biothrips, and Filbio, are available in a range of mesh sizes and can be used to protect against a variety of pests, including flea beetles. These provide less heat and greater air circulation than spunbonded row covers, though for early spring crops, the additional warming benefit of traditional row covers of various weights may be preferred.

Chemical control. Maturing plants should be scouted frequently. When plants are young, an average of 1 beetle per plant or 10% average leaf damage is a reasonable threshold for chemical intervention. Several synthetic pyrethroids (Group 3A), carbamates (Group 1A), neonicotinoids (Group 4A, either as foliar or soil drench), and the relatively new diamide class (Group 28) are labeled for flea beetle in brassicas. Avoid repeated use of one type of chemistry over multiple generations or using both soil and foliar applications of the same group. Note that as of 2012, the registration for Thionex has been cancelled and is no longer allowed on cole crops. Soil-applied systemic insecticides, such as Admire Pro and Actara can provide longer term control against damage, although beetles may still be seen when scouting. Products containing the new active ingredient cyantraniliprole, a diamide (Exirel for foliar applications; Verimark for soil), are labeled for flea beetle and have been shown in trials to have good efficacy against this pest. Be aware that systemic insecticides may have longer days to harvest intervals. With foliar sprays, even if good control was achieved, re-infestations can occur rapidly and may require additional sprays.

For organic farmers, the choice of chemistries includes spinosad (Entrust) and pyrethrin (Pyganic). In UMass trials, Entrust showed the greatest efficacy in suppressing flea beetles and reducing damage, while Pyrethrin (Pyganic EC 5) showed poor to moderate efficacy in our trials. However, Pyrethrin is reported by growers to cause a significant short-term knockdown. Abby Seaman, NYS IPM, found in 2012 trials that both kaolin (Surround WP) and hot pepper wax worked well. They did not prevent enough feeding for salad greens to be marketable, but they did prevent enough feeding for broccoli, cauliflower, cabbage, etc. to outgrow the damage. In 2013 NYS trials, Entrust, as well as both Venerate and Grandevo, two OMRI-approved bioinsecticides, were all found to significantly reduce damage from flea beetle on cabbage under low pest pressure. Another promising organic product is Azera, a mix of azadirachtin and pyrethrins. A 2011 University of Maryland trial found that Azera significantly reduced flea beetle feeding damage, and that mixed with Surround, it both reduced feeding damage and maintained efficacy over time.

Control brassica weeds. Brassica weeds also harbor flea beetles (both adults and larvae) and reduce the efficacy of your crop rotation schemes that aim to break the pest cycle by changing crop families. Yellow rocket, wild mustard, and shepherd's purse are familiar weeds that are widespread in fields and roadsides. The list of weed hosts probably also includes garlic mustard (*Alliaria petiolata*), a serious invasive weed in the brassica family. It is a biennial with white blooms in May. It thrives in roadsides and field edges as well as shady woodlands, and has rapidly spread throughout Massachusetts. A good fact sheet on garlic mustard can be found at: http://www.nps.gov/plants/alien/fact/alpe1.htm or through the Invasive Plant Atlas of New England (IPANE) website.

Trap cropping. Take advantage of the flea beetle's preferences for particular brassicas by using the preferred species or varieties as a draw. Their numbers will build up in the more attractive plants, and are less likely to move into or stay in those less preferred. A border or even a middle row planted to *Brassica rapa* or *B. juncea* crops such as Komatsuna, tatsoi, mizuna, bak choi, and mustard has been shown to reduce numbers and feeding damage on less preferred *B. oleracea* crops such as broccoli, cabbage, or traditional kale (eg, Winterbor types). Red Russian kale (*B. napus*) and Lacinato kale (*B. oleracea*) seem to be of intermediate attractiveness. To make it work, here's some tips:

- Make sure the trap crop is established before the main crop (the one you are trying to protect) or is at least as big (e.g. transplanted same day). Direct-seeded crops can be used around transplants if seeded 7-14 days earlier.
- Use a fast-growing, vigorous cultivar for the trap crop.
- Use a border crop to prevent beetles from moving farther into the field. Traps at ends of rows help make a complete perimeter, which stops beetles coming from all directions. Interior trap crops also can act as a 'sink' within the field.
- Spray only the trap crop to kill the accumulated beetles and to avoid having to spray the main crop. You also want to keep the trap crop viable enough to do its work and potentially be harvestable as well. Use a longer-residual product, if possible.
- Combine with a repellent on the main crop, such as Surround WP and garlic sprays.

Effect of push/pull system. Kale treated with Surround is protected from damage while untreated bok choy draws flea beetles, where they can be sprayed (hopefully before they cause this much damage!) Photo: S. Scheufele

A variation on this theme is the push-pull system, in which most of the brassica crop is treated with a repellent such as Surround, to "push" the beetles to a sensitive crop (e.g. bok choy or mustard), which is left untreated. This strategy limits the amount of time and material used in controlling the pest, since you only need to spray the "pull" crop, instead of all of the brassica acreage with an insecticide. The trick is to catch the beetles on the sensitive crop before they cause too much damage there, or make the "pull" crop something you don't intend to harvest, like an extra row of direct-seeded mustard. We saw this work really well on a farm in MA where flea beetles had built up to very high levels and were a major production challenge. When the farmers combined this strategy with crop rotation, separating spring from fall fields and going into a field that had been out of brassicas several years, the results were impressive. So there is hope!

Resource: Hazzard, R. "Materials for Beating Flea Beetles in Brassicas". New England Vegetable and Fruit Conference, 2005 Conference Proceedings: http://www.newenglandvfc.org/2005_conference/sessions_05/biorantional_biological_pest_control/Materials%20for%20_Beating%20Flea%20Beetles%20in%20Brassicas%20.pdf

--Updated by L. Mckeag and S. Scheufele, Umass Extension, Vegetable Program.

Dickeya Blackleg: New Potato Disease Causing Major Impact

Dickeya has already been confirmed this year in FL, VA, and NJ in germinating potato of several varieties. As potatoes begin to emerge in Massachusetts, we thought it would be a good time to publish the following article from Meg McGrath.

By Meg McGrath, Associate Professor of Plant Pathology, Cornell University Long Island Horticultural Research & Extension

Dickeya blackleg, often just called Dickeya, is a new disease in the USA. It is caused by the bacterium, *Dickeya dianthicola*. This aggressive pathogen has the potential to cause more severe losses than species of *Pectobacterium* (aka *Erwinia*) causing the type of blackleg that has been occurring. High temperatures (exceeding 77 F) are favorable for Dickeya, consequently the greatest losses have been in the southern portion of the northeast (especially the mid-Atlantic region) and further south. Total crop loss has occurred. Dickeya was severe in 2015 at least partly reflecting hotter weather than previous 2 years when the pathogen likely was present. This new disease is developing again in 2016.

Early symptoms of Dickeya; a wilted plant. Photo: M. McGrath

Symptoms. First symptom is poor emergence (skips in a production field) due to rotting seed. Plants that emerge from contaminated seed wilt and typically have black stems extending upwards from rotting seed piece. Occasionally, especially late in the season, only internal stem tissue will be discolored. The fact stem symptoms start at the seed and progress upward illustrates that *Dickeya dianthicola* is in potato seed. Symptoms typically develop following a period of hot weather especially when plants are also stressed. In 2015 on Long Island a lot of plants dropped out during flowering.

Blackleg caused by *Pectobacterium* differs from Dickeya in that it starts on the outside of stem tissue, infects through wounds, and then moves downward as well as upward causing stem rot that is dark brown. Affected tissue typically has an offensive odor and is slimy. In contrast, plant tissue affected by Dickeya typically has an earthy smell; occasionally it has an offensive smell indicating soft rot bacteria are also present.

Initial stem symptoms. Photo: M. McGrath

Plants affected by Dickeya can just appear unthrifty if they have a sub-lethal titer of the bacterium.

No symptoms may develop when the temperature never becomes hot during the growing season.

Additional photographs are at: http://livegpath.cals.cornell.edu/gallery/potatoes/potato-blackleg-caused-by-dickeya/

Management. Dickeya is a destructive pathogen that cannot be managed when present in production fields. There are no resistant varieties and no effective fungicides. This bacterium is not known to be able to survive in soil more than about two months, which is not long enough to be able to serve as a source of inoculum the following growing season. Research is underway to try to confirm this under a range of conditions. Potato seed that is free of Dickeya is the best management practice for this disease. One challenge is that symptom development is limited by cool temperatures that are typical in seed producing areas: the pathogen can be present in a plant but cause no distinctive symptoms (wilt or black stem). Unfortunately there is not a reliable seed testing procedure identified yet. Infected seed can appear healthy. Dickeya is developing in crops established in 2016 with seed that tested negative with the dormant tuber test. There is differing opinion about whether there should be no tolerance for Dickeya, similar to bacterial ring rot, in certified potato seed or whether a low percentage of contaminated seed can be tolerated as is the case with other diseases such as late blight. A major difference is that there are resistant varieties and effective fungicides for managing late blight.

Field planted with Superior potato seed from two sources. Poor emergence and other symptoms of Dickeya only found for one seedlot. Photo: M. McGrath

Additional information.

Potato Blackleg: What We Know About an Emerging Problem

Presentation by Keith Perry, Plant Pathology, Cornell, at the 2016 Empire State Producers Expo Potato Session

Dickeya dianthicola affecting potato growers throughout Mid-Atlantic region
Web posting by Andy Wyenandt, June 2016

NEMATODES FOR INSECT CONTROL

by Vern Grubinger, Vegetable and Berry Specialist, University of Vermont Extension, Published: August 2005

Nematodes are small worms. Really small – microscopic, in fact. They're sometimes referred to as roundworms or eel-worms. Some nematodes are friends, some are foes, and some could be considered neutral. It all depends on their eating habits. Of the thousands of kinds of nematodes, some feed on insects, some eat plant roots, while others consume bacteria or are parasites of animals.

Nematodes are found all over the world in many kinds of habitats. For farmers, the nematodes of interest are soil-dwellers that either attack crop roots (bad nematodes) or feed on insect pests (good nematodes).

Bad nematodes. These are called plant parasitic nematodes. They either attack plants from the outside (ectoparasitic) or they live inside the host plant for part of their lives (endoparasitic). Both these nematodes inject saliva into their host plants that results in damage, either by killing tissue or causing the creation of many giant cells that form galls. There are many kinds of plant parastic nematodes, and most have a relatively narrow host range. A few nematodes, such as the root-knot nematode and the root-lesion nematode, attack many kinds of crops. Damage from nematodes includes stunting, chlorosis, and root distortion.

Good nematodes. Enough bad news; let's focus on beneficial nematodes, how they work, and how to best use them. The following information comes from the fact sheet "Insect-Parasitic Nematodes for the Management of Soil-Dwelling Insects" by Dr. Mary Barbercheck, Department of Entomology at Penn State University.

Insect-parasitic nematodes help farmers by providing 'biological control' of soil-dwelling insect pests. These nematodes occur naturally in the soil, or they can be purchased and introduced. They are relatively easy to mass produce and are available from several commercial labs as 'biological insecticides' which are exempt from EPA registration. These nematodes can infect many kinds of insects, but they don't infect birds or mammals.

Big names worth knowing. The nematodes commonly used as biological control agents for soil pests belong to the families Steinernematidae and Heterorhabditidae. Some commercially available nematode species are: *Steinernema carpocapsae, S. feltiae, S. riobrave, Heterorhabditis bacteriophora, H. marelatus,* and *H. megidis*. These nematodes are generally used for management of soil insect pests in high value crops.

How they kill insects. These nematodes carry bacteria in their bodies that are toxic to insects. That's why they are called 'entomopathogenic' nematodes. Entompathogenic is the scientific term for 'insect-killing'. The nematodes and bacteria are always found together because they depend on each other. The bacteria need the nematodes to deliver them into the insects, and the nematodes need the bacteria for food and to create conditions in the insect that allow it to reproduce. The bacteria are safe to animals and have only been found in association with these nematodes and infected insects, never living freely in soil.

What Goes Around, Comes Around. Nematodes are only deadly to insects at one stage in their life cycle, called the infective juvenile, or IJ. This is the only time that the insect-pathogenic nematode exists outside of the host insect. Infective juvenile nematodes in the soil seek out insects then enter them through their natural body openings. Once inside the insect body, the nematodes release their bacteria, which multiply and eventually kill the host. But not before the nematodes develop into adults, reproduce, and produce offspring. A few weeks after the initial infection, the new generation of nematodes develops into infective juveniles, and thousands of them emerge from the dead insect and search for new insect hosts in the soil.

Applying Insect-Parasitic Nematodes. Because these are living organisms special attention needs to be paid to their handling, application, and selection of species to match the crop. Nematodes need adequate moisture, moderate temperatures, and protection from direct sunlight during application. Their natural home is in the film of water around particles of soil, so commercial formulations of beneficial nematodes are usually soil-applied. They should not be sprayed on plant foliage unless specifically formulated for that use.

Nematodes are typically applied in water at a rate of about 1 billion per acre, depending on the crop. They can be applied with conventional chemical application equipment, but nozzle filters or screens smaller than 50-mesh will clog and it is best to remove screens in nozzles when applying nematodes with a back-pack sprayer or spray rig. Care should be taken when using hydraulic pumps that have high internal pressure and high shear force as these will shred the nematodes.

Nematodes tend to settle in the tank, so agitation must be provided for uniform application. Nematodes can be killed by excessive tank agitation through sparging (recirculation of a portion of spray mix) or excessive mechanical stirring that is used to keep the nematodes in suspension. Pump pressure above 300 pounds per square inch or temperatures above 85°F will kill nematodes.

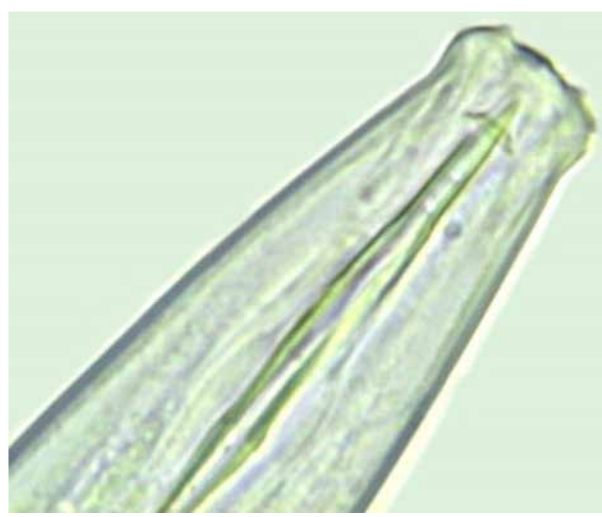
It is best to apply nematodes to moist soil in the early morning or late evening when air temperatures are between 60 and 85°F. A pre-application irrigation can be applied to moisten the soil and a post-application irrigation can be applied to wash any nematodes on plant surfaces to the soil surface. The post-application irrigation should be applied before spray droplets dry and must provide a tenth to a quarter inch of water to allow the nematodes to move into the upper soil layers, out of sun or drying air exposure. Applications can be made before or even during a rainfall to wash nematodes to the soil surface.

Successful application of nematodes is influenced by spray volume. Most nematode labels suggest volumes of two to six gallons of spray per 1000 square feet (87-260 gallons per acre). This is achievable for many boom sprayers and lawn shower nozzle sprayers that are equipped with sufficiently large nozzles. Some turf applicators use shower nozzles that deliver 1 to 1.5 gallons of spray per 1000 square feet. When lower spray volumes are used, pre- and post-application irrigation can be adjusted to counteract the problem of low volume sprays and to assist in moving the nematodes to the soil and off exposed surfaces.

Nematodes can also be applied with irrigation. However, some irrigation systems, especially low volume trickle systems, may not move water fast enough to keep nematodes suspended. When in doubt, check periodically by taking a sample at the emitters to determine if live nematodes are being moved through the system.

When Do They Work, and Why? Success using nematodes for insect control has been mixed. Their effectiveness has been highest in highly controlled systems such as nursery containers and mushroom houses where environmental conditions highly suitable for the nematodes can be maintained. Besides improper conditions, most failures with field applications are due to a poor match between the nematode species and target insect pest. Using the right kind of nematode for the insect pest you wish to control is critical because nematode species vary in their host range and in their host-finding behavior.

Some nematodes are very active in the soil ('cruisers') and search around for a host insect, while some tend to sit and wait for a host insect to pass by in close proximity ('ambushers'). Cruiser nematodes will be more effective than ambushers at finding a sedentary insect host, like white grubs. The ambushers are effective at infecting active insect hosts, such as cutworms or mole crickets. Some known appropriate pathogen-host targets are *S. glaseri* against the Japanese beetle; *S. scapterisci* against mole crickets; *S. riobrave* against cutworms and citrus weevils; and *S. feltiae* against sawfly larvae and fungus gnat larvae.



Steinernema feltiae (*mouth pictured here*), *is an omniverous nematode that enters the insect through natural openings, then releases toxic bacteria which spreads and kills the insect. Photo: R. Wick*

As with any purchased natural enemy, quality of the product can affect efficacy. Quality of the product can be affected by batch, and shipping, storage, and application conditions. Nematodes are living organisms and are subject to destruction by excessive cold or heat, and lack of moisture or oxygen. A small sample of the mixed product should be checked with a hand lens or magnifying glass to observe living, moving nematodes. Nematodes that are very straight and motionless may be dead, and therefore, ineffective.

Events

Water Management Twilight Meeting

When: Wednesday, June 28, 2017 from 4pm-6pm with dinner to follow!!

Where: Tangerini's Spring Street Farm, 139 Spring St, Millis, MA 02054

FSMA and drought got you down? Come to this Twilight Meeting at Tangerini Farm in Millis, MA. Tour the newly installed irrigation system for orchard and vegetable crops built with funding support from NRCS with the designer, Trevor Hardy of Brookdale Farm, Irrigation and Row Crop Supply. Find out water sampling protocols and lab requirements for FSMA from the UMass Food Safety Specialist Lisa McKeag and about grant opportunities for irrigation and food safety improvements. Other industry representatives will be available for consultation and **dinner will be provided** following the tour.

We will cover: irrigation water sources, sampling for FSMA requirements, ins-and-outs of drip irrigation, overhead irrigation in corn, strawberry and direct seeded crops, irrigation under FSMA, and orchard irrigation.

Thank you to our sponsors

Vegetable Notes. Katie Campbell-Nelson, Lisa McKeag, Susan Scheufele, co-editors.