UMass Extension
# Vegetable Notes
For Vegetable Farmers in Massachusetts since 1975

Volume 28, Number 18 August 11, 2016

## In this issue:



## Crop conditions

It's National Farmers' Markets week. Massachusetts farmers are leaders in direct marketing, responsible for 30 percent of New England's total direct sales, and second in the nation after Connecticut for direct to consumer sales. Keep up the good work! So, what is coming out of the fields to be sold at markets this week? We have reached the peak of summer bounty with harvests including sweet corn, eggplant, melons, peppers, greens, tomatoes, carrots, beets, potatoes, onions. Many of the earliest potatoes such as Red Gold have been dug and are curing. In a year without late blight (so far), some were lucky enough to survive the hopperburn on their potatoes and are scratching their heads; should they mow or burn tops now so that potatoes will cure faster in the field? Due to the droughty conditions, some are still seeing germination of beets and carrots now, 3-4 weeks after planting, with not enough moisture in the soil to even break down the clay coating on some pelleted seeds. Weeding has been tricky in these sporadically germinating crops. UMass Extension and Waltham Fields Community Farm co-hosted a twilight meeting yesterday at Tangerini's Spring Street Farm in Millis yesterday. Charlie and Laura Tangerini welcomed a great turnout, despite the threat of rain (finally). They highlighted the cultivation practices used on their farm and showed off some of their favorite pieces of equipment. Laura emphasized that cultivation has become a whole new game with these changing weather patterns, and the same old set of tools and practices don't seem to be enough. Charlie and co-manager Steve demonstrated their Cress finger weeder mounted on a Fobro toolbar which they use to weed their fields in just 1 hour per week, saving them the cost of a 4-person weeding crew for the summer. After a tour of the pack shed and some new equipment in there too, Lisa McKeag gave a thorough update of the various food safety programs and regulations in Massachusetts. A summary of her presentation may be found here: Farm Food Safety in Massachusetts. All in attendance finished the day with a delicious meal catered by the farm and were grateful for the rain.

*Charlie and Steve demonstrate their 3-row cultivator setup at this week's twilight meeting at Tangerini's Spring Street Farm*

## Pest alerts

**Allium:**

Be sure to inspect crops carefully as they cure and go into storage, or as they are being distributed, and cull any problematic alliums so that infections don't spread in storage. **Slippery skin** of onion has been reported in VT. This bacterial diseases causes break down of internal tissues leaving the outer skin intact. **Waxy breakdown of garlic** has also been reported in VT (photo). This is a physiological condition which occurs during high heat conditions near time of harvest or due to poor ventilation and low oxygen in storage.

*Waxy breakdown of garlic. Photo, A. Hazelrigg*

**Brassica:**

Cabbage aphids were found in Franklin and Hampshire Cos., MA, particularly in centers of cupping/heading cabbage and in growing tips and some young sprouts of Brussels sprouts. Not as many as we've seen in previous years at this location, but they're present and in hard to reach places. Unlike other aphids that lay eggs and overwinter on alternate hosts, cabbage aphids overwinter on brassicas. Even though heavy infestations are not typically found until fall, eggs hatch and start colonizing plants in April. It is not surprising with more year-round brassica production that cabbage aphid infestations are occurring earlier in the year. Treat if >10% of the plants are infested with aphids, especially after heads or sprouts begin to form.

Alternaria leaf spot has been diagnosed on fall brassicas in Hampshire and Franklin Cos., MA. With morning fog and slightly rainier weather, this disease is likely to spread. Till under old brassica crops and increase airflow by keeping crops well-weeded to reduce spread of this disease. Spores overwinter in crop residue in soil. This disease is favored by warm temperatures (60-78° F) and at least 12 hours of relative humidity of 90% or more. This fungus sporulates profusely and is spread throughout fields by wind, splashing water, equipment, and workers. The main means of introduction into new areas is on infested seed.

Flea beetle second generation is active and aggressive this year and fall brassicas are at risk; particularly the youngest transplants. Broccoli crops scouted were at threshold in Norfolk and Hampshire Cos., MA this week. On young plants, threshold is 1 beetle per plant or 10% average leaf damage.

Cross-striped cabbage worm was found this past week infesting kale in Franklin Co., MA and Brussels sprouts in 2 Hampshire Co., MA fields. Other brassica caterpillars were also found this week but not at threshold in a fall brassica crop in Franklin Co. See article this issue for more information on managing caterpillars in brassicas.

Table 1. Accumulated Growing Degree Days (°F): 1/1/16 - 8/10/16

| Location | GDD (base 50F) |
|---|---|
| **Western, MA** | |
| Ashfield | 1534.7 |
| South Deerfield | 1747 |
| Pittsfield | 1469.8 |
| **Central, MA** | |
| Bolton | 1789.4 |
| Northbridge | 1651 |
| Phillipston | 1543.4 |
| **Eastern, MA** | |
| Ipswich | 1605.2 |
| Sharon | 1857.1 |
| Waltham | 1830.5 |
| Seekonk | 1876.2 |
| **Hollis, NH** | 1698.7 |
| **Burlington, VT** | 1820.1 |
| **Newport, RI** | 1678.6 |

With multiple pests infesting brassica crops now, growers are using pesticide cocktails to protect their fall crops. For example: Dipel for caterpillars, Entrust for flea beetle and M-Pede for aphids, with nozzles directed both to sides and centers of plants.

**Cucurbit:**

Sudden vine collapse or wilt reports have come in from many growers in VT and MA recently. Causes can include **Fusarium crown rot** (would see rotted crown), **Pythium** (would see a root rot), bacterial wilt (bacterial streaming from stems would be present) and a fairly new disease called **sudden vine collapse**. This disease is caused by the fungus *Monosporacus*. Symptoms include sudden collapse and loss of secondary and tertiary roots. The pathogen forms black fruiting bodies on the roots with distinctive spores. Ann Hazelrigg at the Vermont diagnostic lab found fruiting bodies on the roots of a melon sample but they are not producing the cannonball-shaped spores associated with this pathogen. Ann suspects any earlier root damage would be exacerbated by the heat, drought and heavy fruit load. Past reports of vine collapse have been on watermelon, muskmelon, butternut, and kabocha. *Monosporacus* is known to cause infection in melon crops in the field, but not winter squash.

Anthracnose leafspot was diagnosed on cucumber from Hampshire Co., MA. The pathogen survives between crops in infected crop debris, volunteer plants, or weeds of the cucurbit family. It can be spread by cucumber beetle feeding, as well as by splashing water, workers, and equipment. Frequent rains, warm temperatures (74-78° F), and high humidity favor the development of anthracnose.

Cucurbit downy mildew **was** diagnosed this past week on pickling cucumbers in Chittenden Co., VT and on cucumber in Long Island, NY. Look for yellow, angular leafspots on the upper leaf surface and dirty, gray spores on the leaf undersides. This means that downy mildew specific materials should be included for fall cucumbers now in MA. Thorough coverage is necessary. See suggestions in this February 2016 issue of Vegetable Notes.

**Lettuce:**
Bottom rot in Hampshire Co., MA around the same time wire stem on brassicas were reported. Both diseases are caused by the same organism, *Rhizoctonia solani.* Treat transplants with Rootshield or other fungicides before placing in the field if the field has a history of this pathogen.

*Lettuce bottom rot*
*Photo, S. Scheufele*

**Solanaceous:**
**Bacterial canker** caused by *Clavibacter michiganensis* pv. *michiganensis* was confirmed on one variety of yellow pepper from Franklin Co., MA., likely seed borne. This disease can be effectively managed with hot water seed treatment. **Blossom end rot** has been widely reported on tomatoes this year, not necessarily due to lack of calcium in soils, but due to irregular or insufficient supplies of water, causing the plant to be unable to get calcium all the way to the growing ends of fruit.

**Sweet corn:**
**European corn borer** second flight has peaked and larvae have hatched. Our scout found a 76% infestation in one untreated succession in Hampshire Co., MA with equal numbers of ECB and **fall armyworm** caterpillars. Meanwhile another field in the same county scouted 2 days later was completely caterpillar free. Both farms had used *Trichogramma* releases to manage ECB. Do not depend on trapping data from our network alone to make spray decisions; rather, scout your own fields using protocols found in this publication: Sweetcorn Insect Management Record Keeping Book. Overall, trap captures of all moths including corn earworm are low across the state (see table), but field infestations may be present and crops should be treated if there remain more than 5 days before harvest. Many **syrphid fly larvae** were found in scouted corn. They normally eat aphids, but can also feed on small ECB larvae!

We've heard that growers are getting good results keeping blackbirds out the corn they're picking by using wavy, generator-powered scarecrows, like the ones you see at used car lots (see photo) , but like all scare devices, they need to be moved frequently.

*Scare device in a corn field - people like them, but birds don't!*
*Photo, K. Campbell-Nelson*

* When not given here, refer to the New England Vegetable Management Guide for scouting thresholds and treatment options.

Table 2. Corn pest trap captures week of 8/3/16 - 8/9/16

| Location | ECB Weekly Total | FAW Weekly Total | WBC Weekly Total | CEW Weekly Total | Spray Interval for CEW |
|---|---|---|---|---|---|
| **Western, MA** | | | | | |
| Sheffield | 1 | 5 | 6 | 2 | *6 days* |
| South Deerfield | 0 | 1 | 7 | 0 | *No spray* |
| Whately | 1 | 3 | - | 3 | *6 days* |
| **Central, MA** | | | | | |
| Bolton | 3 | 2 | - | 4 | *5 days* |
| Leominster | 0 | - | - | 2 | *6 days* |
| **Eastern, MA** | | | | | |
| Concord | 0 | 0 | - | 0 | *No spray* |
| Haverhill | 11 | 0 | - | 1 | *No spray* |
| Ipswich | 3 | 5 | - | 4 | *5 days* |
| Millis | 0 | - | - | 3 | *6 days* |
| Sharon | 0 | - | - | 16 | *4 days* |
| Seekonk | 4 | - | - | 3 | *6 days* |
| Swansea | 4 | - | - | 8 | *4 days* |
| Tyngsboro | 8 | 0 | - | 0 | *No spray* |
| **NH** | | | | | |
| Litchfield | 0 | 48 | 0 | 0 | *No spray* |
| Hollis | 0 | 17 | 0 | 1 | *No spray* |
| Mason | 0 | 3 | 0 | 0 | *No spray* |
| **Cortland Co., NY** | 1 | 15 | 69 | 0 | *No spray* |

European corn borer (ECB), Fall armyworm (FAW), Western bean cutworm (WBC), Corn earwom (CEW)

# BLACKLEG OF POTATO CAUSED BY THE BACTERIUM *DICKEYA DIANTHICOLA*

*Symptoms of blackleg caused by* Dickeya dianthicola *on an infected potato plant.*
*Photo, Rutgers Plant & Pest Advisory*

**What is this Dickeya anyway?**
The bacteria that cause blackleg of potatoes were once considered to belong to the species *Erwinia carotovora* and *Erwinia chrysanthemi*. *E. carotovora* was the cause of blackleg in North America, while *E. chrysanthemi* was common in warmer parts of Europe, the Middle East, and Australia. Molecular work on the genetic makeup of the genus *Erwinia* led to the re-classification of the blackleg-causing strains of *E. carotovora* as members of the genus *Pectobacterium*, while some strains of *E. chrysanthemi* were assigned to a new genus, *Dickeya*. There are currently six recognized species of *Dickeya*.

Presently, *Pectobacterium atrosepticum* and *P. carotovorum* subsp. *carotovorum* are the species that most commonly cause blackleg in North America. Potato blackleg caused by *Dickeya solani* and *D. dianthicola* has been a growing problem in Europe over the past decade. It has likely existed in the United States for some time, but until recently, *Dickeya* was rarely reported on potatoes in the U.S. In 2015, *D. dianthicola* was first identified as the cause of blackleg on potatoes in the eastern U.S.

**How is disease caused by *Dickeya* similar to that caused by *Pectobacterium*?**
Both *P. atrosepticum* and *D. dianthicola* can cause blackleg on potatoes in the Northeast. Symptoms caused by the two pathogens are sometimes similar: water-soaked lesions beginning at the base of the stem and turning dark brown to black as the infection progresses up the stem, pith decay, wilting/ yellowing leaves, plant collapse, and soft rot of tubers. Poor emergence may occur as a result of rotting seed potatoes.

**How is *Dickeya* different from *Pectobacterium*?**
Both bacteria are active at a range of temperatures; however, the optimum temperature for disease development for *Dickeya* is greater than 25°F, while it is less than 25°C for *Pectobacterium*. While symptoms caused by the two bacteria are similar in moist conditions around 25°C or less, when temperatures are higher and the weather is dry, *Dickeya* can cause a dry rot with hollowing of the stem. Leaves begin to turn brown and vascular discoloration may be observed in leaf veins. Stems typically remain green until leaves are completely desiccated. These symptoms can easily be confused with those caused by drought stress, hopperburn or wilt diseases such as *Verticillium*. *Dickeya* is considered to be a more aggressive pathogen, able to cause disease at lower inoculum levels and spread more quickly through the vascular system. On the bright side, *Dickeya* is a poor soil competitor and it is believed that it cannot survive in the soil for more than two years. In contrast, *Pectobacterium* is believed to survive in soil for up the three years.

**Where do these bacteria come from and how do they spread?**
The primary source of inoculum for both species is infected seed potatoes. *Dickeya* can remain dormant in seed potatoes stored at low temperatures, and infected seed potatoes may show no signs of rot before planting. Bacteria multiply when temperatures warm and then move from the seed into the soil, where they can be carried by irrigation water to nearby plants. Bacteria can also be transmitted by movement of contaminated soil, farm equipment, and insects. Infected tubers remaining in the soil over the winter can produce infected volunteer plants in the spring.

**How do I manage *Dickeya* blackleg?**

- Management practices for blackleg remain the same regardless of whether the cause is *Pectobacterium* or *Dickeya*.
- Plant clean seed. Obtain seed from a reliable source.
- Examine seed for any signs of rot before planting. Use uncut seed if possible. If using cut seed, allow time for adequate suberization before planting.
- Rotate away from potatoes for at least three years. Avoid Brassica and Allium species.

- Eliminate volunteer potatoes that appear in rotation crops or along field margins.
- Sanitation is crucial. Clean all equipment and tools used in planting, cultivating, and harvesting potatoes. There is some debate as to whether or not bleach is effective, but other disinfectants such as quaternary ammonium, copper quinolinolate, and hydrogen peroxide and/or peroxyacetic acid are effective.
- Plant in an area with good air circulation and well-drained soil.
- Avoid overfertilization.
- Scout fields regularly for symptoms of disease. Carefully rogue infected plants if possible.
- Keep cull piles as far away as possible from potato fields.
- Harvest in dry weather after vines have died back completely.
- For long-term storage, store potatoes for 1-2 weeks at 50-60°F (10-15°C), then reduce the temperature to 38-42°F (3-5°C).
- Copper based products may provide some protection to uninfected plants.

Accurate diagnosis is important for the efficacy of any disease management program. For information on submitting samples to the UMass Plant Diagnostic Lab for analysis, please see http://ag.umass.edu/diagnostics

**References**

USDA-APHIS. 2015. Best Management Practices for Prevention and Control of Blackleg Disease in Potatoes. https://www.aphis.usda.gov/plant_health/plant_pest_info/potato/downloads/dickeya/blackleg-%20prevention-control.pdf

Al-Mughrabi, K. 2016. Dickeya: A New Threat to Potato Production in North America. http://spudsmart.com/dickeya-new-threat-potato-production-north-america/

Kleczewski, N. 2016. Dickeya Blackleg Updates and Considerations for 2016 Potato Crops. http://extension.udel.edu/fieldcropdisease/2016/03/29/dickeya-blackleg-updates-and-considerations-for-2016-potato-crop/

*-- Angie Madeiras, UMass Plant Disease Diagnostic Lab,*

## CATERPILLARS IN BRASSICA CROPS

We've been seeing lots of caterpillars in all the sundry brassica crops for several weeks now (except for the migratory cabbage looper, which has not had many opportunities to come up North on storm fronts this summer). Though they may all look alike, the four major brassica caterpillar pests are different species and there are important distinctions among them that can affect your management decisions. They differ in size and feeding habits, as well as how susceptible they are to beneficial parasitoid insect species, and certain insecticides. Getting acquainted with the pests helps you to know what kind of damage to expect and what to look for when scouting for their different life stages and biocontrols. Feeding damage by any of these caterpillars can reduce yield and marketability of both leafy and heading crops.

*Imported cabbageworm butterfly (top) and larvae (bottom)*

**Imported cabbageworm, cabbage butterfly** (*Pieris rapae*) is a very familiar white butterfly which can be seen in the daytime fluttering around brassica fields. Each forewing has a dark border and one or two round black spots. Eggs are laid singly on the underside of leaves, standing upright (see b. in photo). They are slightly elongated, kind of bullet-shaped, about 1/8 inch in length, and initially pale white, but turning to yellow as they mature. The larva is gray-green, slightly fuzzy, and sluggish but can be very well camouflaged. Feeding and resting occur on the underside of leaves, and larvae feed more heavily in the head of cabbage or broccoli as they develop. The overwintering stage is the crysalis (pupa), which is green or brown, smooth with

three pointed ridges on its back. There are 3-4 generations per year.

*Diamondback moth larva*

**Diamondback moth** (*Plutella xylostella*) adults are tiny (<1/2 inch), light brown, and rest with their wings folded together like a tent. They overwinter in crop residue, but may also enter the region by migrating from southern states. Eggs are laid singly or in small clusters (see a. in photo). Caterpillars go through four instars and are small (<1/2 inch when fully grown), light green, and appear segmented, with a forked end and pointed shape. When disturbed they wiggle vigorously and may drop off the plant and hang on a string of silk. Feeding causes small, round holes and tends to be spread across the foliage and not necessarily concentrated in the head.

*Cabbage looper larva*

**Cabbage looper** (*Trichoplusia ni*) usually does not survive the winter in New England and arrives in migratory flights from farther south. Generally populations of cabbage loopers are not high until late-July or August, though some years they are not found at all or earlier flights occur. Adult moths are mottled gray-brown, about 3/4 inch long, with a distinct round silver-white mark on each fore-wing. Since they fly at night, they are rarely seen unless monitored with pheromone traps. If you want to know when moths arrive, use a wing trap baited with *Trichoplusia ni* lure, placed near the canopy. Eggs are round, pale green or yellow, and are laid singly underneath the foliage (see c. in photo). The cabbage looper caterpillar is light green, smooth, with wavy white or light yellow lines down the back and sides, and prolegs at the tip of the abdomen. Full-grown larvae reach 1 ½ to 2 inches. Cabbage loopers of any size will raise the middle of their body in a characteristic "loop" shape, as an inch worm would. Feeding tends to create ragged, large holes in foliage, on both frame leaves and heads. Cabbage looper also feeds in many non-brassicas including lettuce, celery, spinach, and chard so when they do arrive, scout those crops as well as brassicas.

*Eggs of different caterpillar pests: (a) Diamondback moth, (b) Imported cabbageworm, (c) Cabbage looper)*

*Cluster of cross-striped cabbageworm eggs*

**Cross-striped cabbageworm** (*Evergestis rimosalis*) is relatively new to New England. We first listed it in the New England Vegetable Management Guide around 2005, because it had become common in Connecticut. By 2012 it was found in Hampshire, Worcester and Norfolk Counties in MA. Its damage is similar to that of other caterpillars but it can be even more damaging if populations are high. One of the major differences between this insect and the other brassica caterpillars is that the eggs are laid in a group (see photo), and caterpillars feed in a group on one plant so that it's covered with big holes like buckshot.

Cross-striped cabbageworm (CSC) is closely related to European corn borer, and the adults are similar in shape and coloring--straw-colored with a little purple, and crossed by wavy lines. Since it flies at night, you will likely only notice the caterpillars and their damage. The clusters of 3 to 25 eggs are yellow, flattened, and attached to the lower leaf surfaces. The caterpillars are light bluish-grey on top and green underneath, with numerous black transverse bands across their backs and a yellow line down each side. Larvae grow to 3/4"-long in 2 to 3 weeks. There are 2-3 generations per year, but generally it's only in late summer that numbers reach damaging levels. Larvae can produce small holes in leaves until only veins remain, feed in terminal buds and sprouts, or burrow into heads. Plants with larvae are often completely skeletonized. Adjacent plants may be left undamaged.

*Cross-striped cabbageworm larva*

**Field Scouting and Management.** It is especially important to check cabbage or broccoli plantings as they begin forming heads. Greens such as collards and kale should be scouted earlier, since all leaves are marketed. Check at least 25

randomly-selected plants throughout the field, looking for caterpillars or fresh feeding damage on the top or underside of leaves. Feeding damage can be found on the underside of leaves or in the center of the plant where heads are forming. Look for black or green frass and tiny feeding holes, clustered together. Often it is easier to spot the frass and feeding damage first, then find the caterpillar. Classify plants as infested (one or more caterpillars present) or non-infested, and calculate the percent of plants infested. In the Northeast, there is generally no need to treat young plants unless weather conditions delay plant development and at least 35% of them are infested with any of these pests. Treat heading crops between the start of heading and harvest if 15-20% or more of the plants are infested. The most critical time to scout and apply controls is just prior to head formation. For leafy crops like kale and collards where all leaves are marketed a 10-15% threshold should be used. Because cross-striped cabbageworm can be so destructive, a lower threshold should be used--treat when 5% of plants are infested with this pest.

**Insecticide applications.** Use at least 50 gal spray material/A; higher volumes provide better coverage. Better coverage of lower leaf surfaces can also be achieved by using drop nozzles. Use a spreader-sticker. Use selective insecticides to protect beneficial insects that keep aphids under control, eat insect eggs and small caterpillars, and parasitize either ICW or DBM. Selective products often are most effective when consumed with foliage so coverage is important. Effective, selective insecticides include:

- *diamides* (Group 28) including chlorantraniliprole (Coragen, 3 dh, REI 4h, Bee toxicity: L)
- *spinosyns* (Group 5) including spinetoram (Radiant, 1 dh, REI 4h, Bee toxicity: M) and spinosad (EntrustOG,1 dh, REI 4h, Bee toxicity: M) - *also effective against flea beetles and onion thrips*
- *Bacillus thuringiensis* (Group 11) products including *Bt aizawi* (XenTariOG , 0 dh, REI 4h, Bee toxicity: L) and *Bt kurstaki* (such as Dipel DFOG and many other products, 0 dh, REI 4h, Bee toxicity: L) – *these materials will ONLY affect caterpillars*

These materials and the *aizawai* strain of *Bt* will usually provide better control of resistant DBM than older products. See the cabbage/insect control section of the New England Vegetable Management Guide for additional synthetic and naturally derived products and more details.


*Cotesia rubecula larva in ICW*

**Cultural and Biological controls.** Incorporate crop residues shortly after harvest to reduce movement to successive plantings and reduce overwintering populations. Populations are suppressed by a wide range of natural enemies. There are several species of wasps that are important parasitoids of brassica caterpillars. Diamondback moth eggs are parasitized by the ichneumon wasp, *Diadegma insulare*, which occurs naturally in Eastern North America. *D. insulare* females require sources of nectar to be effective DBM parasitoids, so maintain wildflower stands near brassica fields. The braconid wasp, *Cotesia rubecula*, was introduced to New England from China in 1988, and is now established in Massachusetts. This wasp parasitizes imported cabbageworm eggs. You may see their small white cocoons on brassica leaves. The chalcid wasp, *Trichogramma brassicae*, will lay its eggs in many species of caterpillar, including all of the brassica pests above (as well as non-target caterpillars, so be cautious if you *are* maintaining wildflowers that might attract endangered moths or butterflies). These wasps are not found in New England, but can be purchased from several biological control companies for release in brassica fields. The wasps arrive as pre-parasitized caterpillar eggs that are glued to cards that can be distributed throughout the crop. Each card costs around $16-$20, and contains about 100,000 wasps, which is enough for up to 1 acre. According to one source of *T. brassicae* wasps, IPM Labs Inc., some growers will release one card per acre per week for about 4 weeks, while others will release every week for the life of the crop, and will release the wasps in lieu of using any kind of pesticide. These biological controls are compatible with many selective and lower impact sprays (*Bt*, oils, soaps) used for control of caterpillars or other pests, particularly since the wasps are protected from sprays for longer than they are vulnerable, as much of the time they are unreachable inside of their host eggs. Another source, Evergreen Growers Supply, notes *Trichogramma* wasps are more effective against moth species that lay their eggs in clusters, so may be a good option if cross-striped cabbage worm has been a particular problem.

*--R. Hazzard, S.B. Scheufele and L. McKeag*

# USING COPPER FUNGICIDES

Copper products play an important role in disease management in both conventional and organic fields. They are the most effective controls for most bacterial diseases. In organic production, copper products are the main protectant fungicide used in the control of diseases caused by oomycetes such as late blight and downy mildews. There are more copper products becoming available, and it is helpful to understand the differences and benefits of different active ingredients and formulations. Solubility, phytoxicity, human health risks, impact on soil ecology, labeled crops and diseases, and efficacy are important considerations in using particular copper products.

**How copper works.** When copper (Cu) is mixed with water, copper ions ($Cu^{2+}$) are released into solution. Modern copper products typically use insoluble or "fixed" forms of copper, creating a suspension of copper molecules in the spray solution. These un-dissolved copper particles persist on plant surfaces after the spray dries and copper ions are released from these deposits each time the plant surface becomes wet. The gradual release of copper ions from the copper deposits provides residual protection against plant pathogens present on the leaf surface. Copper ions kill pathogens primarily by destroying cell membranes and proteins and by disrupting protein synthesis. Since the mode of action of copper targets such fundamental components of living tissues, it affects a wide range of plant pathogens including bacteria, fungi, and oomycetes, but can also damage plant cells and be toxic to humans and other non-target organisms. Achieving the best control without injuring plant foliage and fruit depends on the concentration and rate of release of copper ions on the leaf surface, which is determined largely by the solubility of the copper formulation.

**Solubility**

- Less soluble (fixed) formulations release copper ions more slowly. This slow-release lowers the risk of phytotoxicity and provides longer residual activity. The following are low-solubility active ingredients: copper oxide (e.g., Nordox), copper hydroxide (e.g., Kocide, Champ), copper oxychloride (e.g., COCS and BadgeX2), and copper octanoate (copper ions linked to fatty acids to form a soap, e.g., TennCop, Cueva).
- More soluble formulations act rapidly but have higher risk of phytotoxicity and shorter residual activity. Basic copper sulfate and copper sulfate pentahydrate are highly soluble.

**Metallic Copper Equivalent.** Product labels list percent active ingredient (eg., 23.8% copper oxychloride or 98% basic copper sulfate), but this doesn't tell you the actual metallic copper by weight, as the formulation also impacts the total copper present. Look for the "metallic copper equivalent" listed below the active ingredients to determine the amount of actual copper by weight. A product with 40% metallic copper has 0.4 lb metallic copper per lb of product. The range in MCE among products is vast, ranging from under 1.8% to over 50% copper by weight, so it is important to consider the MCE because the effectiveness of a copper spray is highly correlated to the amount of copper applied.

**Effects of pH, Spray Additives, and Weather**

- Under acidic conditions, copper solubility and the potential for phytotoxicity increases. Spray solutions should be kept above pH 6-7, depending on the formulation, to prevent excessive amounts of copper ions from being released and possibly damaging fruit and foliage.
- Adding maneb or mancozeb to copper products as a tank mix increases the release of copper ions in solution. There are pre-mixed products (e.g., ManKocide) available, or growers can make their own mixtures. This may be especially helpful for controlling bacterial diseases such as bacterial speck, spot and canker of tomato.
- Using an approved adjuvant or 'sticker' may help the product to be more rainfast, but when used with the highly soluble copper sulfate formulations, can cause phytotoxicity.
- Finely ground compounds will be more active than coarser ground materials because the smaller particles result in better coverage of the leaf and are less likely to be removed from the leaf by wind and rain.
- Copper can accumulate to high levels on plant tissue when sprayed repeatedly to cover new growth and there is no rain. In this situation, after a rain event, a large amount of copper ions may be released leading to phytotoxicity.
- The risk of plant injury increases when the spray solution dries slowly due to cool wet weather, as the duration of active release of copper ions on the leaf is increased.
- Always read the label instructions. When mixing, follow the tank mix partner instructions.
- For each product, application rates vary with crop and disease. The recommended rate for a given crop may have a 2-fold difference between the high and low rate. Higher rates are recommended when disease pressure is high or

conditions are especially favorable. Most products are labeled for a wide range of vegetable crops.

**Safety**

**Human Health Hazards.** Eye exposure is the most serious risk associated with using copper hydroxide. Eye damage can be irreversible. There is moderate risk from skin contact, ingestion and inhalation. Products vary in EPA hazard rating, most are "Warning" or "Danger" but Badge SC has a lower risk "Caution" label. The greatest health risk is to the person who mixes and sprays the material. Proper protective equipment should be worn when handling or applying copper products as with any pesticide or fertilizer. The required protective equipment is specified on the label and usually includes: long-sleeved shirt and long pants, chemical resistant gloves made of any waterproof material such as polyethylene or polyvinyl chloride, shoes plus socks, and protective eyewear. Though not usually required, you may also want to consider wearing a respirator or dust mask, especially for mixing dry formulations. Dry product sometimes comes in a paper bag that has a tendency to leak out of the seams and needs additional containment such as a plastic bin.

**Restricted Entry Interval (REI).** Most copper products have an REI ranging from 24-48 hours, which means that workers are not allowed to go into treated fields to pick fruit or do any other field work for that duration of time. Plan your spray and harvest schedule to accommodate your marketing needs as well as the REI. Fruit may need to be polished before marketing, to remove the blue residue left on fruit. Be sure to wear proper PPE, as described on the label.

**Environmental Hazards.** Some farmers have expressed concern about copper toxicity in the soil or with respect to soil microbes and earthworms. Additionally, copper can be very toxic to fish and aquatic organisms, if drift and run-off occur. This should be a concern in sandy, acidic soils or near surface water. Copper is actually an essential plant micronutrient and, in New England, it is more often deficient than excessive in soils. The amount found naturally in soils in MA ranges from 0.1 to 8 ppm while nationally soils range up to 200 ppm. Crops remove less than 0.1 lb/A copper per year. Copper usually accumulates on the soil surface where it becomes chemically bound to organic matter and clay minerals. In acidic soils, the solubility of copper increases and toxicity or run-off may occur. An application of 1 lb of active ingredient per acre is estimated to raise the copper levels about 0.5 ppm. A single application of Nu Cop at 2 lb per acre with 77% active ingredient adds about 1.5 lb copper per acre to the soil, or could raise the concentration in the soil by 0.5 to 0.75 ppm. Therefore, the level of copper in soil would increase slowly over time, except in perennial planting systems such as apple orchards. In annual rotational systems, where copper applications might only be made every 4-6 years, copper accumulation is less of a concern. Nonetheless, copper use is regulated and certified organic farmers in the US are required to restrict their use of copper products. Regular soil tests should be taken and copper levels in the soil should be monitored.

**Managing blights in organic tomato and potato using copper**

Copper-based fungicides are labeled for use in organic systems and have demonstrated effectiveness in preventing late blight. Copper fungicides do not kill infections that are already present, they must be used preventatively in order to effectively protect plants from infections. Most pathogens have latent periods, when the plant is infected but does not show any symptoms. Thus, when symptoms appear, it is too late to protect the crop effectively–-especially with late blight. Some strains of late blight are more aggressive than others and this will also influence the efficacy of copper spray programs. Regular applications of copper will also help protect tomatoes from early blight and Septoria leaf spot, which can progress rapidly and cause plantings to produce far less than their full yield potential.

Several copper products are OMRI-listed for use in certified organic production and are registered for use in Massachusetts including: NuCop 50DF, Badge X2, Basic Copper 53, and Cueva. Check the OMRI website for updates or consult your certifier. As with insecticides, dry formulations are more commonly approved for use in organic systems. Note that OMRI approval is for specific formulations, and there are often multiple formulations with the same trade name (eg. Badge X2 and Badge SC, of which only Badge X2 is OMRI approved).

**High Tunnel and Greenhouse Considerations**

- Read the label to be sure that a product is not restricted from use in the greenhouse. Many copper products are.
- The same protective gear and restricted entry interval would apply.
- Apply with sides open for ventilation.
- Most labels require that in addition to the standard REI, an eyewash station and notice of eye risk should be available for 7 days after application.
- If you suspect late blight, have the disease identified. Fulvia leaf mold, powdery mildew, and Botrytis gray mold

or ghost spot are common diseases in high tunnel tomatoes and can look very much like late blight.

- If tomatoes (or other crops on which copper is used) are grown in the same area year after year, and copper is used, build-up in the soil is more likely. Include copper levels in your annual soil testing. Rotate to other crops!

*-- S.B. Scheufele and R.Hazzard. Adpated from T. Zitter & D. Rosenberg, Cornell Plant Pathology, E. NY Commercial Horticulture Weekly Vegetable Update. June 26, 2013.*

# Events

## IPM Climate and Weather Conference

**When:** Monday, August 15th, 2016 from 9am - 4:15pm

**Where:** Albany County Cornell Cooperative Extension, 24 Martin Rd., Voorheesville, NY 12186

Organized and hosted by the New York State Integrated Pest Management Program (NYS IPM)

Supported in part with funding from Cornell Cooperative Extension

A wide variety of speakers from New York and the Northeast will provide background information on the current state of knowledge on climate change, changes in our weather patterns, and how collecting climate and weather data can help us predict and manage pests. Topics include climate change; agricultural, forest and landscape pests; human health; decision tools; and weather monitoring. Open discussion sessions are included so you can ask questions. Katie Campbell-Nelson, from UMass Vegetable Program will present on *Weather forecasting andmodeling for diversified vegetable growers*.

Cost: $45. Pre-registration closes on **August 10**. If you have questions, please contact Amanda Grace at arw245@cornell.edu or 315 787-2208.

## Hopping and Milling About at Four Star Farms

**When:** Thursday, August 18, 2016 from 10:30am to 3:00pm

**Where:** Four Star Farms, 496 Pine Meadow Rd., Northfield, MA 01360

The UVM Extension Northwest Crops & Soils Program invite you to attend this Hops Field Day. We will join the L'Etoile Family to hear about hops, as well as tour the yards. After a great lunch, you will hear about grains processing – from field to flour. They will also discuss their SARE grant regarding trap crops for potato leaf hoppers, and you will receive updated research from Heather Darby and her program team.

The cost is $25 per person and you can register online – www.regonline.com/hopsandgrainsatfourstarfarms.

## The 32nd Annual Massachusetts Tomato Contest

**When:** Wednesday, August 24th, from 9am-1pm

**Where:** Boston Public Market, corner of Congress St. and Sudbury St. Boston, MA

The contest will be held in the KITCHEN at the Boston Public Market (entrance is on the corner of Congress St. & Sudbury St.). Tomatoes will be judged by a panel of experts on flavor, firmness/slicing quality, exterior color and shape. Always a lively and fun event, the day is designed for commercial growers with the goal of increasing awareness of locally grown produce. The 32nd Annual Tomato Contest is sponsored by the Massachusetts Department of Agricultural Resources, New England Vegetable and Berry Growers Association and Mass Farmers Markets in cooperation with the Boston Public Market and The Trustees of Reservations.

For more information or questions regarding the Tomato Contest contact Julia.Grimaldi@state.ma.us, 617-626-1763.

## SARE Grant Webinars

**Writing a Northeast SARE Partnership Grant Application Webinar**

**When:** Sep 01, 2016 11:00 AM EDT

Register at: https://attendee.gotowebinar.com/register/3512176966032896002

In this 60-minute webinar, Carol Delaney, Northeast SARE Farmer Grant specialist, will review the Partnership Grant program, including its purpose, allowable expenses, and funded project examples. She will also provide tips to writing a compelling application. The webinar is open to the public, especially to non-profit organization staff and others interested in applying.

**Northeast SARE Farmer Grant Program: Tips for Writing a Compelling Application**

**When:** Sep 01, 2016 12:30 PM EDT

Register at: https://attendee.gotowebinar.com/register/3376350996119085058

In this 60-minute webinar, Carol Delaney, Northeast SARE Farmer Grant specialist, will review the Farmer Grant program, including its purpose, allowable expenses, and funded project examples. She will also provide tips to writing a compelling application. The webinar is open to farmers, agricultural service providers, and others interested in learning about Northeast Farmer grants.

**Managing Phosphorus in Organic Residuals Applied to Soils**

**When:** Wednesday, November 2, 2016 from 8:45-4pm

**Where:** Holiday Inn, 265 Lakeside Ave.Marlborough, MA 01752

How do we develop a balanced system for use of organic residuals, with all their benefits, without adding to negative environmental impacts caused by phosphorus (P) leaching and runoff? This symposium will provide technical, research-based information and dialogue on the presence, forms, dynamics, transport, and fates of P applied to soils in organic residuals such as composts, biosolids, manures, and digestates from anaerobic digestion. This symposium is intended to help in developing guidelines for the use of P-containing organic residuals in accordance with nutrient management regulations.

Approval has been requested for the following professional certifications: CGCS, CSFM, MCH, MCLP, and AOLCP.

**Event Website:** https://www.regonline.com/phosphorus

**Contact:** Kelly Kraemer, 413-545-5221, kkraemer@umass.edu

# Sponsors



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

*Where trade names or commercial products are used, no company or product endorsement is implied or intended. Always read the label before using any pesticide. The label is the legal document for product use. Disregard any information in this newsletter if it is in conflict with the label.*