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NEWSLETTER

Utah Plant Pest Diagnostic Laboratory

USU Extension

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EXTENSION

UtahStateUniversity

High Tunnel Arthropod Pest Management

High tunnels can extend the growing season in a cold location such as northern Utah.

Use of high tunnels or field greenhouses is a popular production method in Utah to substantially extend the length of the growing season. Tunnels can provide benefits beyond temperature regulation, such as increasing humidity, shading, and reducing populations of some pests through exclusion and concealment. However, some insect and related pests can thrive in the plastic-covered environment. If plants are irrigated with driplines, the dry soil between plant rows is a conducive location for ant nests. Moist, shaded plants can be attractive to slugs and earwigs. Other common high tunnel pests in Utah include thrips, spider mites, aphids, leafminers, whiteflies, flea beetles, and grasshoppers.

Early detection through regular and thorough plant inspections is important for effective pest management. In addition to visual inspections, gently shake plants over a light-colored tray or sheet to collect dislodged insects. Use a hand lens (10-30× magnification) to help with identification of small insects and mites.

Some of the primary tactics that can be used to effectively suppress pests in high tunnels include:

- Place floating row cover over susceptible plants for concealment and to exclude pests that have entered the high tunnel. Row covers, or low tunnels, can exclude insects that fly or jump onto plants, including thrips, flea beetles, leafhoppers, whiteflies, aphids, leafminers and grasshoppers. Additionally, curly top virus infection of tomato, pepper and other susceptible host plants tends to be very low where the vector, beet leafhopper, is excluded.
- To physically remove small arthropods, such as aphids, mites, thrips and whiteflies, wash down plants with a stiff spray of water from a hose-end nozzle. Repeat every 2-3 days until pest numbers subside.
- Use lower toxicity insecticides with physical modes of action, such as insecticidal soap and horticultural and plant oils, to suppress soft-bodied insects

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Diane Alston
Entomologist
diane.alston@usu.edu
435-797-2516

Ryan Davis
Arthropod Diagnostician
School IPM Associate
ryan.davis@usu.edu
435-797-2435

Marion Murray
IPM Project Leader
Utah Pests Quarterly Editor
marion.murray@usu.edu
435-797-0776

Cami Cannon
Vegetable IPM Associate
Graphic Design, Utah Pests
Quarterly Newsletter
cami.cannon@usu.edu
435-797-2435

Claudia Nischwitz
Plant Pathologist
claudia.nischwitz@usu.edu
435-797-7569

Ricardo Ramirez
Entomologist
ricardo.ramirez@usu.edu
435-797-8088

Lori Spears
USU CAPS Coordinator
lori.spears@usu.edu
801-668-4056

Utah Plant Pest Diagnostic Lab
BNR Room 203
Utah State University
5305 Old Main Hill
Logan, UT 84322

To subscribe, click here.

utahpests.usu.edu

and mites. Apply early in the morning or evening when temperatures inside the tunnel have dropped below about 80°F to avoid injury from 'burning' of plant leaves.

Spider mites can thrive in the hot conditions of a high tunnel.

- Use biological insecticides, such as Bt (*Bacillus thuringiensis*) for caterpillars, and spinosad for thrips, earwigs, and leafminers. Use a molluscicide containing iron phosphate for slugs and snails.

Thrips are a common pest of cucumber, squash and melon grown in high tunnels.

- Pavement, harvester, and field ants are the most common ant pests of plants in northern Utah. Apply homemade or commercial ant baits to suppress nearby ant colonies. Pavement ant food preferences vary with the needs of the colony. They prefer a variety of foods, including sweets, greases, proteins, and seeds. Boric acid is an effective active ingredient that can be added to homemade ant baits. See Ryan Davis' comprehensive article on homemade ant bait recipes in the Spring 2016 Utah Pests News edition (page 8).

Pavement ants can feed on plants, and are attracted to dry soil inside high tunnels for building nests.

- When high tunnels are fully enclosed, they can be an effective site for releasing biological control agents. It is critical to select the correct species of natural enemy to target each pest species, as food preferences can be narrow. Additionally, select natural enemies well-suited for the environmental conditions at the time of release.
  - The USU publication, Greenhouse Biocontrol in Utah provides information for biocontrol agents in high tunnels, including where to purchase.
  - The Sustainable Agriculture Research and Education (SARE) fact sheet titled Sustainable Pest Management in Greenhouses and High Tunnels by Judson Reid, Cornell University, provides additional details on selection and release of biological control agents.

For more information on pest management in high tunnels in Utah, see the Utah Pests News Spring 2012 edition (page 3) for an article that includes disease prevention strategies and more.

—— Diane Aslton, Entomologist

Elm Seed Bug

Elm seed bug adults hiding under overlapping elm leaves.

Elm seed bugs are on the rise this summer. Since mid June, the UPPDL has received many calls concerning elm seed control. Elm seed bugs are most prevalent on and in structures that have nearby elm trees. Their small size allows them to easily enter houses through sliding windows, doors, and even picture windows.

Appropriately labeled pyrethroid insecticides applied as a barrier perimeter treatment around foundations, windows, doors and eaves may provide some relief from migrating bugs. However, reports from callers indicate that immediate kill of elm seed bugs from at least two pyrethroid insecticides - bifenthrin and lambda-cyhalothrin - does not occur and entry into the home may still take place before elm seed bugs die. If you have had pesticide applications made for elm seed bug, please contact the UPPDL to discuss the product used and its performance.

Late-stage immature elm seed bug.

Fecal spots of elm seed bugs on a window frame.

Elm bugs are very small and excluding them from the home is the primary control method, but it can be difficult. Focus on sealing windows and doors. Windows are a particularly favored entry point. Even if you have new windows or picture windows, elm seed bugs may infiltrate around the frame, tracks, or even between the glass and frame. Exclusion efforts must be extremely thorough to be effective. Inside, vacuum bugs that enter the home.

For more information see the new Utah Pests fact sheet on Elm Seed Bug.

——— Ryan Davis, Arthropod Diagnostician

Choosing the Best Traps for Controlling Pocket Gophers

Dr. S. Nicole Frey is a Wildland Resources Associate Professor with USU Extension. Her work focuses on solving wildlife management issues in southern Utah. She also teaches Principles of Natural Resource Management at Southern Utah University, is involved in 4-H at the national and state level for the Wildlife Habitat Evaluation Program, and serves as the Continuing Education Coordinator for the Jack H. Berryman Institute.

Pocket gopher (left) and pocket gopher mound (right).

Valley pocket gophers (*Thomomys bottae*) are a common agricultural pest in many areas of Utah, Nevada, and California. Pocket gophers predominantly eat roots, although they will pull vegetation into their burrows, and eat plants immediately adjacent to their burrow holes. In a survey conducted by USU Extension in the 1990s, agricultural producers in Utah reported that pocket gophers were one of the most abundant threats to production. Because pocket gophers are active year-round, farmers require management options to protect their crops throughout the season. Removing pocket gophers via lethal control during their breeding season (March –April) is often the most effective method because this removes the adult population and reduces the potential for juveniles during that season.

Using strychnine baits is a common method to control gophers, but acquiring the bait and timing this method with the gophers' reproductive season can be tricky, when we often have snow on the ground through March. Traps are another form of pocket gopher control, and are often used in conjunction with baiting as an integrated pest management strategy. Trapping effectiveness is dependent on the type of trap, the crop, soil type, and the size and sex of the pocket gopher. Trapping is more labor intensive than baiting, and therefore understanding the variability in the time efficiency of trapping success can assist in developing the most effective IPM strategy.

In 2015, we compared the effectiveness and efficiency of three types of kill traps—Macabee, DK-1, and Cinch—in 4 alfalfa fields in Beaver County, Utah. Beaver County ranks 10th in the state in the number of acres in hay, grass silage, and greenchop production. The study began the first week of April and continued for 6 weeks. We chose the April date to ensure that we were trapping during the breeding season and to determine which trap would be most effective if used once alfalfa had begun to grow.

We found the Macabee trap to be the most effective at trapping pocket gophers (Table 1) and the most time-efficient trap (Figure 1). The trap is easy to use and has an appropriate size. Macabee traps caught more pocket gophers per total visits to the trap, but there were also a large number of traps tripped or plugged each week. It is possible that the Macabee traps, while attracting the most attention, were unable to capture larger animals. This could cause animals to become trap shy, ultimately reducing the possible effectiveness of the control program. Therefore, we recommend modifying the pinchers of the Macabee to allow it to catch larger animals. This study is not meant as a comparison to larger operations or those with a different growing season and climate than what is found in the Intermountain West's Great Basin. However, there are very few studies of valley pocket gopher control in this region, and thus these results may assist Intermountain West farmers in the future.

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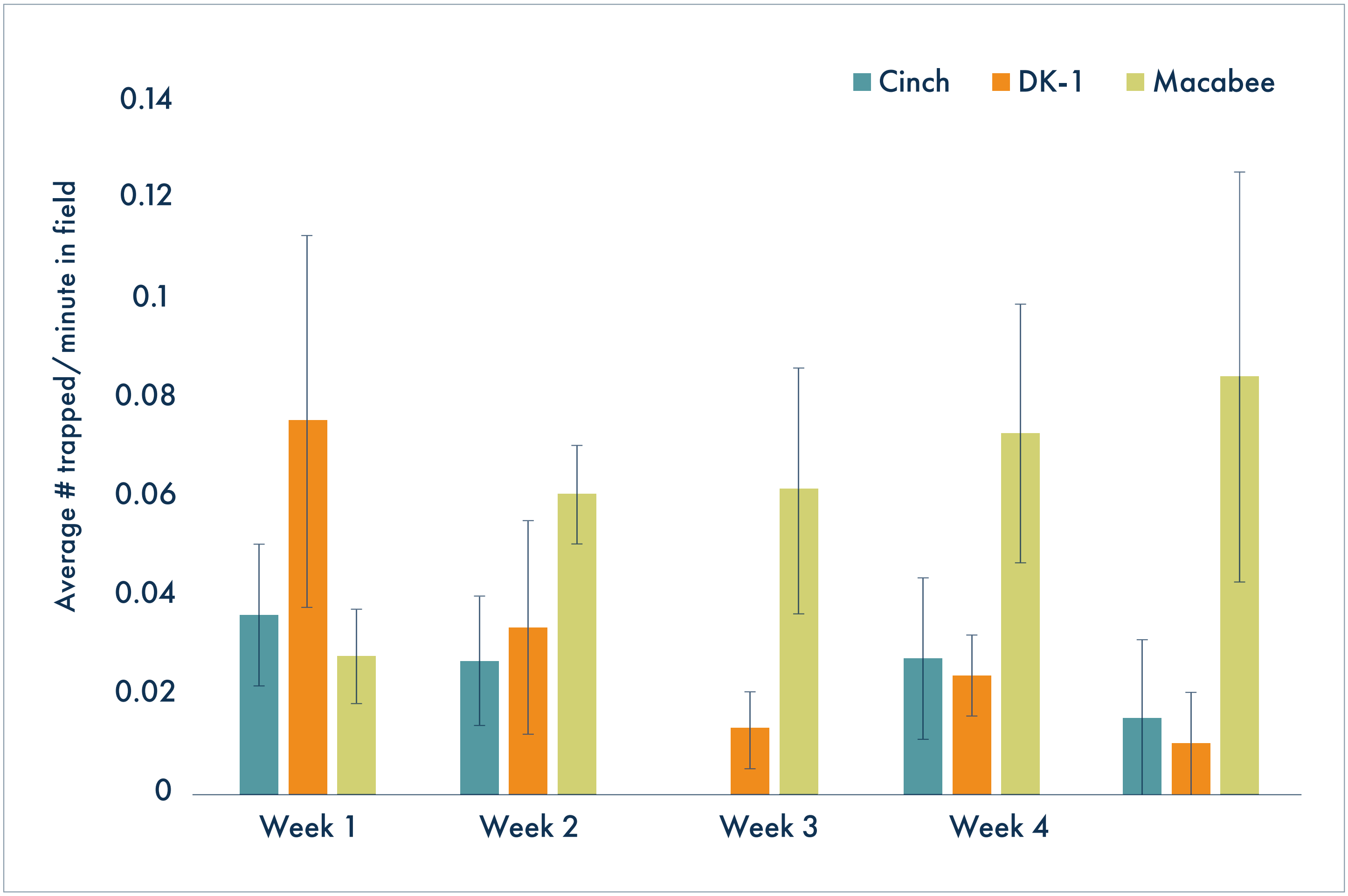
Table 1 Average # of Pocket Gophers Trapped, Set Tripped or Plugged, and Average Duration in the Field by Treatment Type

Trap Type	Ave. # trapped per week (± standard error)	Ave. # tripped or plugged per week (± standard error)	Ave. duration in field (minutes) per week (± standard error)
Cinch	0.5 ± 0.16	1.2 ± 0.30	29 ± 3.5
DK-1	0.9 ± 0.27	2.3 ± 0.41	36 ± 2.4
Macabee	1.4 ± 0.22	2.5 ± 0.40	34 ± 3.0

Figure 1



Excerpted from: Frey, S. N., and Nelson, M. (in press). Fine tuning pocket gopher management (Thomomys bottae) in alfalfa fields of southern Utah. Proceedings of the 27th Vertebrate Pest Conference, 2016.

—— Featured Author Dr. S. Nicole Frey, Wildland Resources Specialist

Pest Spotlight: Gypsy Moth

When it comes to non-native invasive species, it is best to heed Ben Franklin's advice that "an ounce of prevention is worth a pound of cure." In other words, the best way to fight invasive species is to prevent them from becoming established in the first place. USU Extension and Utah Department of Agriculture and Food work together to prevent invasive species through education and outreach and to detect, monitor, and control invasive populations within the state, in part through the Utah Cooperative Agricultural Survey (CAPS) program.

Gypsy moth (GM) is one of Utah's most "unwanted" invasive pests and is a significant risk to our trees and shrubs, in both urban and forested areas. Larvae consume the foliage of hundreds of tree species. The most preferred hosts include apple, aspen, birch, oak, and poplar, but they will also attack cherry, elm, hickory, honeylocust, maple, walnut, and several conifers. They defoliate trees, leaving them more susceptible to drought, diseases and other pests. With repeated attacks, GM can eventually kill trees and entire forests. In urban settings, GM can be a nuisance problem as the larvae crawl all over homes and outdoor furniture, and egg masses can be found on many outdoor surfaces, including trees, houses, patio furniture, and vehicles (see below for identification information).

There are two GM subspecies of concern to the U.S.—the European GM (*Lymantria dispar dispar*) and the Asian GM (*L. dispar asiatica*), although the two subspecies can only be distinguished from each other by DNA tests. The European GM is well-established in the eastern U.S. and has been detected in many other parts of the country. In recent years, there have been several introductions of Asian GM to the U.S., including Washington and Oregon. In Utah, the Asian GM has not been detected, but populations of European GM have been found and eradicated twice (1988 and 1999). In 2016, a single European GM was detected in the Bountiful area of Davis County. The Utah Department of Agriculture and Food – Plant Industry and Conservation has led GM trapping and eradication efforts. In spring 2017, they placed a delimiting grid of traps around the 2016 detection site to determine if other GM are present in the area and if so, the extent of the infestation.

Despite these trapping efforts, homeowners are encouraged to keep their eyes open for this destructive pest. A description of their life stages is found below. Please report suspect infestations to Lori Spears (lori.spears@usu.edu) or Kris Watson (kwatson@utah.gov). For more information, visit USU's gypsy moth website.

- Adult males are grayish-brown moths with feathery antennae and a wingspan of about 1 1/2 inches. Adult females have creamy white wings with black wavy markings, thread-like antennae, and a wingspan of about 2 1/2 inches. Both males and females have an inverted V-shape that points to a dot on the wings.
- Eggs occur in conspicuous, velvety masses that are 1-2 inches long, tan in color, and firm to the touch. The eggs inside are black and pellet-like. Egg masses may contain between 100-1,000 individual eggs.
- Young larvae are small, black caterpillars with black hairs; whereas older larvae have tan bristles, five pairs of blue spots followed by six pairs of red spots lining the back, and yellow spots along the sides of the body. Larvae are 2 1/2-inches long when fully grown and can occur in large groups (100+).

—— Lori Spears, USU CAPS Coordinator

—— Kristopher Watson, UDAF State Entomologist

Downy Mildew of Spinach

In spring 2017, downy mildew (*Peronospora farinosa* f. sp. *spinaciae*) was found on spinach in a Utah greenhouse. Although the disease is common and very destructive in major spinach production areas in the world, this is the first documented case in Utah. The pathogen is very host specific and is only known to infect spinach. However, some scientists have suggested that it may be able to infect weeds in the genus, *Chenopodium* (goosefoots). If that is the case the pathogen could survive in the farmscape even after infected spinach has been removed.

Spinach is susceptible to infection under cool and humid conditions. The primary symptom on the upper leaf surface is chlorotic spots, while on dark grey fungal growth is usually visible on the lower leaf surface. Spores produced in the leaves are dispersed by wind and splashing water. Symptomatic leaves are not marketable. If infected but non-symptomatic leaves are bagged and sold, symptoms can develop and the pathogen can decay the leaf tissue while stored in bags.

Spinach downy mildew is difficult to control with fungicides. For fungicides to be effective, they would have to be applied before infection occurs as a preventative. Some fungicides that can be used include Aliette 80 WDG, Ridomil Gold, Revus or copper-containing products. Some of the fungicides have post-harvest intervals that need to be taken into consideration before application. A better option than fungicides is the use of downy-mildew-resistant spinach varieties.

Unfortunately, spinach downy mildew keeps evolving to form new "races" to overcome the resistance of the varieties. Currently, there are 16 known races, and many spinach varieties list the races they are resistant to. The variety of the diseased spinach from Utah is reported to be resistant to races 1 and 2. To identify the race found in Utah, we sent samples of the spinach to a specialized lab in Arkansas. For downy mildew prevention, the best option is to use a variety that is resistant to many races.

Spinach Varieties with Known Resistance to Specific Downy Mildew Races

Variety	High Resistance	Intermediate Resistance
3665 (F1)	Races 1-5, 8, 9, 11-12, 14	
Anna (F1)	Races 1, 3, 5	
Baker (F1)	Races 1, 3, 5, 8, 9, 11, 12, 14	
C2-606 (F1)	Races 1-9, 11-16	
C2-608 (F1)	Races 1-7, 9, 11, 13, 16	
Carmel (F1)	Races 1-11,13	
Corvair (F1)	Races 1-12, 13	
Emperor (F1)	Races 1-10	
F91-415 (F1)	Races 1-2	
Flamingo (F1)	Races 1-11	Races 12-13
Gazelle (F1)	Races 1-13	
Kookaburra (F1)	Races 1-13, 15	
Persius (F1)	Races 1-3, 5, 8, 9, 11, 12, 14, 16	
Red Kitten (F1)	Races 1-13, 15	
Reflect (F1)	Races 1-11	
Seaside (F1)	Races 1-12	Race 14
Space (F1)	Races 1- 3, 5-6, 8, 11-12	
Viceroy (F1)	Races 1-2	
Woodpecker (F1)	Races 1-15	

Claudia Nischwitz, Extension Plant Pathologist

CRISPR DNA Technology for Managing Pests

Genetic techniques have been used for decades to assist with pest management. One of the more well-known is the insertion of new genes into plants via genetic modification. For example, the Bt-cotton plant is able to produce the Bt toxin to resist caterpillar pests. More recently, "gene editing" technology provides a more powerful tool that has the potential to permanently eliminate a target insect pest. Ethical debates abound, but this new tool is gaining strong interest in the research community. In fact, Science Magazine called this technology the "Breakthrough of the Year" in 2015 because of the potential application to agriculture and medicine.

The CRISPR System

Clustered Regularly Interspaced Palindromic Repeats (CRISPR) is the name of the new gene tool. It allows for precise editing to delete, add, or replace a specific set of genes, changing the organisms' physical characteristics. It is said to be precise and efficient, and instead of introducing genes from another organism, it "turns on or off" species-specific traits (for example, disrupting insects' ability to find a mate, reducing fertility, or increasing pesticide sensitivity). The genetic change is then passed on to offspring through a process called "gene drive." With gene drive, the release of just a few individuals within a population could lead to complete establishment of the genetic change within a few years. So far, considerable research has been committed to using CRISPR to fight human diseases spread by mosquitoes such as dengue, malaria, and Zika. But crop pests are also being investigated as a means to reduce pesticide use.

Targeting Crops

- Wine grapes: Researchers at Rutgers University are using CRISPR to make wine grapes that are resistant to downy mildew, a disease that requires multiple fungicide applications in humid areas.
- Tomatoes: A team of microbiologists at University of California-Berkley generated tomato plants that show disease resistance to *Phytophthora*, *Pseudomonas*, and *Xanthomonas* spp., without harming growth or yield.
- Rice: Cornell researchers are using the technique to make rice that is resistant to bacterial leaf streak and blight.
- Citrus: A team from the University of California, Riverside, the University of Florida, UC Davis, and Texas A&M is investigating making orange trees resistant to citrus greening, a bacterial disease threatening the citrus industry.

Targeting Insects

- Spotted wing drosophila: This invasive pest has forced fruit producers to dramatically increase pesticide use in managing it. North Carolina State University researchers have targeted a gene that regulates female development, leading to death of female flies early in their developmental stages. Releasing the mutated flies will cause the number of female flies to decline, which would eventually collapse the population.
- Diamondback moth: Cornell researchers are conducting genetic experiments to eliminate pesticide resistance in this moth, which is a world-wide problem. Others are looking at disrupting the gene for development of the larval abdomen, leading to a range of inheritable defects, such as abnormal prolegs and malformed segments in both male and female larvae.
- Citrus greening: An agricultural company in Florida developed a mutated version of the citrus tristeza virus to attack the bacterium that causes citrus greening. They have applied to USDA for permission to release the virus for testing.
- Codling moth: Geneticists with USDA Agriculture Research Service in Washington have been investigating this primary pest of apples. They found that using CRISPR to turn off a protein in females that is important for mating causes the females to lay fewer eggs, all of which are sterile. Because the edited females cannot lay viable eggs, further research will investigate ways to drive the gene through the population.
- Biocontrol: CRISPR offers a less risky alternative by targeting biological control agents instead of pests, where an advantageous trait rather than deleterious trait is targeted for gene drive. Examples for insect biocontrol agents include quicker response rates to plants being attacked by a pest, the capacity to cope with higher temperatures, and tolerance of certain pesticides. The advantage of targeting beneficials is that there is no risk of irreversible extinction.

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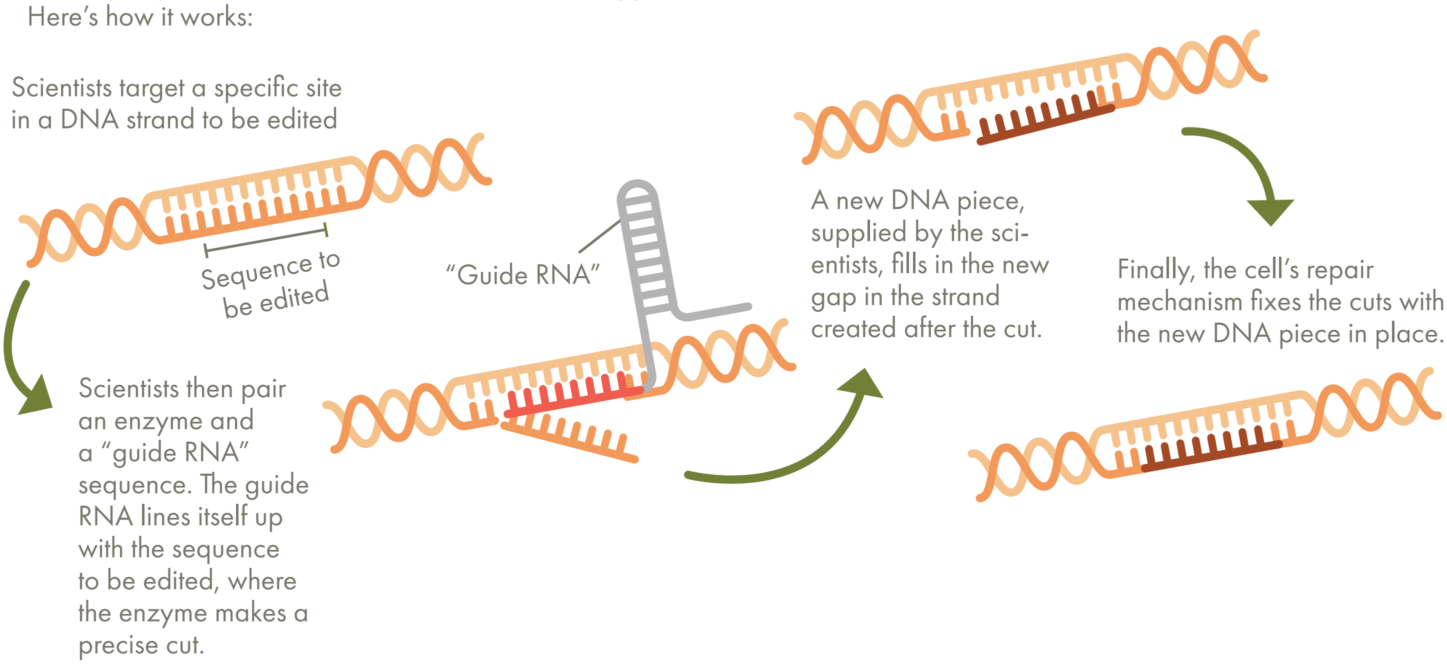
How gene-editing is altering the GMO debate

Adapted from Good Fruit Grower Illustration (Prengaman, 2017)
A gene-editing technique known as CRISPR can make precise genetic changes without transferring DNA from other species. That means crops altered using the procedure are not expected to be subject to current U.S. Department of Agriculture regulations or labeling requirements. But whether consumers will support it remains to be seen. Here's how it works:



To date, all gene editing research on insects has been conducted in controlled environments. Before insects can be released, they must be approved by what are expected to be extensive regulatory reviews by the U.S. government. It is unclear at this point if organisms generated using CRISPR will be considered genetically modified by regulators, since no new genes are introduced. The debate in releasing insects using a gene drive mechanism is just beginning. In December 2016, 160 organizations from six continents released a statement calling for a global moratorium on all work on gene drives, including laboratory research, citing threats to biodiversity, national sovereignty, peace, and food security. In any case, it may take years—if ever—to see commercial application of CRISPR gene drives for insect pest control.

——— Marion Murray, IPM Project Leader

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Neonicotinoid: Retailer Phase-Out and Potential Alternative

Walmart, True Value, Lowe's, Costco, Home Depot, and several other retailers across the country have decided to phase out products containing neonicotinoids. This includes shelf products and treated garden plants. Lowe's specifically announced that it will phase out neonicotinoids in shelf products and plants by spring of 2019, as suitable alternatives become available.

Neonicotinoid pesticides were first registered for use in the mid-1990's and have since become widely adopted for use on crops, turf, trees, and shrubs. Insecticides included in the neonicotinoid class are imidacloprid, clothianidin, thiamethoxam, dinotefuran, acetamiprid, and thiacloprid.

Research has shown that some neonicotinoids—especially when misapplied—can harm bees and other beneficial insects. This has caused concern among the general public and has spurred legal cases, additional research, heightened awareness, increased protective efforts, and a search for alternatives.

A new study released in 2016 identified a potential replacement for industry standard neonicotinoid seed treatments in vegetable crops. The study compared alternatives to the industry standard for snap bean seed treatment of thiamethoxam.

In the processing vegetable industry, crops like snap bean are typically grown using neonicotinoid-treated seeds to control seed and seedling pests like seed corn maggot. Pyrethroids, which can also negatively impact non-target organisms, are used later during snap bean development as sprays to control foliar- and pod-feeding pests like European corn borer.

Cornell professor Brian A. Nault and postdoctoral research associate in the Department of Entomology at Cornell University, Rebecca A. Schmidt-Jeffris, conducted a series of studies to determine if anthranilic diamides, such as chlorantraniliprole and cyantraniliprole, could successfully control the two major pests (seed corn maggot and European corn borer) of the processing snap bean industry.

Their results demonstrated that anthranilic diamides are as effective as neonicotinoids and pyrethroids when applied in the same manner (seed and foliar treatments respectively). They also found that a single seed treatment of chlorantraniliprole has the potential to manage both a seed/seedling-feeding and foliar-feeding pest simultaneously, providing protection throughout the growing season and decreased application costs due to the reduction in labor, fuel, and water use from switching from multiple foliar sprays to a single seed treatment.

Nault and Schmidt-Jeffris describe that while anthranilic diamides have been effective pest control tools, they are more expensive to produce than pyrethroids and neonicotinoids, making it a hard transition. Reduced prices of diamides or decreased availability or efficacy of older materials will likely be needed to change existing patterns of pesticide use. However, with the retailer phase-out and public concern surrounding neonicotinoids, it seems that anthranilic diamides may have a critical role to play in future vegetable pest management programs.

Read more about this study at:

Anthranilic Diamide Insecticides Delivered via Multiple Approaches to Control Vegetable Pests: A Case Study in Snap Bean

——— Cami Cannon, Vegetable IPM Associate

Additional Reading

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Predicting Billbug Management in Intermountain West Turf

Insect development is, in part, temperature-dependent. Development stops when temperatures fall below a lower temperature threshold unique to that species, and resumes as temperatures rise above that lower threshold. Using this premise, researchers and pest management practitioners have developed and used degree-day models as a management tool to predict insect development, activity, and to time management practices.

Degree days are heat units that accumulate over a 24-hour period when the average temperature is above a species-specific lower temperature threshold. Several degree-days can accumulate in 24 hours, especially in hotter temperatures (see USU Degree Day fact sheet). Using local maximum and minimum temperatures, a degree-day equation for a specific pest, and knowing the degree days corresponding to pest events (first flight, egg laying, etc.), practitioners can take the guesswork out of timing management strategies for pests.

In turfgrass, degree-day models exist for black turfgrass ataenius, masked chafer, and bluegrass billbug. Compared to insect management in agricultural settings, the use of degree-day models has not gained as much traction in the turf system. The lack of adoption is unclear but a degree-day approach can be useful in a turf setting where much of the pests' life cycle spent hidden belowground, destructive sampling is needed to find larval life stages, and where pesticide applications tend to be calendar-based.

Given that temperature is a major component of insect development, pest activity varies with weather patterns every year and at every location. Considering this, calendar-based sprays may be too late or too soon. In the eastern U.S., turfgrass professionals have access to WeevilTrak, an online management tool for annual bluegrass weevil, a major pest of turf in the east. WeevilTrak provides end-users with easy access to the degree-day model and site-specific recommendations for treatment timing.

In the western U.S., our primary turf weevil pest is billbugs. Damage from billbugs can be extensive, and some have reported mixed results after applications of systemic insecticides, possibly due to the wrong application timing. In surveys conducted at Utah and Idaho golf courses, PhD candidate Madeleine Dupuy (USU Biology-Ramirez Lab) tracked billbug populations throughout the spring and summer from 2013-2015 to characterize billbug phenology.

Billbug eggs are deposited in turf stems where young larvae begin feeding eventually make their way into the soil where larger larvae damage roots. The result is yellow patches and the possibility of dead turf.

These data were used to evaluate a bluegrass billbug degree-day model developed in the eastern U.S. for its suitability in Utah and Idaho. Dupuy discovered that emergence of billbug adults and their peak activity occurred much earlier than the eastern model predicted. Because the eastern model was found to be inaccurate in predicting adult billbugs in Utah and Idaho, she developed a new model. Using her regional survey data, Dupuy developed and tested the new model that accurately predicts adult billbug activity in the region.

The new Utah-Idaho model uses the single-sine method of calculation, with a start date (biofix) of January 13, and lower development threshold of 34.7°F. For ease of determining degree-day accumulations for billbugs in Utah, the Utah-Idaho model is now available on the Utah TRAPs website. For other locations in the Intermountain West, Dupuy found that the average method of degree-day calculation, an easier degree-day equation, with the new start date (January 13) and threshold (37.4°F) predicts billbug adult activity closely as well.

Although the new Utah-Idaho degree-day model predicts billbug activity, work is still needed to test whether or not the recommended management practices based on billbug activity is useful for our region. Currently, the Utah TRAPs site provides treatment recommendations based on billbug management strategies from research literature in

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the eastern U.S. The model recommends that preventive systemic applications and contact sprays for early adults correspond to degree-day accumulations at or before 986 degree-days, while curative applications correspond with 1433 degree-days.

Dupuy collected billbug adult activity data using linear pitfall traps, a useful tool since billbug adults rarely fly and are active crawlers.

The next step is to fine-tune the model's management recommendations with continued USU research and feedback from a network of turf managers who will test the model. We welcome involvement from any turf professional looking to provide data. As with any IPM approach, the degree-day model is a tool that can better inform management in conjunction with monitoring tools like pitfall traps for adult billbug activity and the tug test for damaging larval stages in soil. Our new knowledge of predicting billbug activity can open opportunities for testing new management approaches.

— Ricardo Ramirez-Entomologist

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Elm Leafminer

Have you noticed brown patches on your elm's leaves this spring? While the blotches might look like a leaf disease, they are actually caused by a tiny insect called the elm leafminer (*Fenusa ulmi*). Elm leafminers are known as sawflies which are wasps, not true flies. The elm leafminer was introduced from Europe along with a few related *Fenusa* leafminers that cause similar damage to birch, alder and *Potentilla* species. Outside of the genus *Fenusa*, there are many leafmining insects from the wasp, beetle, fly and moth orders that affect a wide array of plants.

Typical damage created by elm leafminer larvae.

Elm leafminer damage may be seen every year in Utah, but damage has been heavy in 2017. Symptoms range from thin serpentine trails to blotchy patches to complete consumption of the mesophyll. While rarely noticed, adult elm leafminers may gather on elm leaves or plants below or around elm trees, alarming homeowners. Aggregating leafminer adults will not cause harm to non-elm plants and are not a human health concern. In Utah, Siberian elm (*Ulmus pumila*) is readily attacked by elm sawfly, but other elm species may be susceptible. Interestingly, in other parts of North America, Siberian elm is reported as "resistant" to elm leafminer.

In northern Utah, adult elm leafminers emerge in late April through May after elm leaf expansion. Eggs are inserted into the tops of leaves along the midrib and larger veins, but eggs can be laid anywhere on the leaf surface. Adults are all female, and mating is not required to produce offspring. Eggs hatch in about one week and larvae begin to feed within the leaf mesophyll. Larval mines grow in size as the larva grow. Many larvae typically feed within one leaf and larval mines often coalesce to form large blotches. By mid-June in northern Utah, larvae are fully grown and drop from damaged leaves to overwinter as pupae in the soil. There is one generation per year.

Adult elm leafminers are black, shiny flylike wasps about 3mm in length. They can be noticed basking in the sun on elm leaves or on non-host plants near elm trees.

Adult elm leafminers aggregating on grass below an elm tree.

In most cases, tree health is not severely affected by elm leafminer and intervention is not necessary. Management may be considered for specimen trees where appearance is important. Pesticide applications can target egg-laying females by applying an appropriately labeled pyrethroid or neonicotinoid insecticide to the leaves after leaf expansion throughout the egg-laying period; foliar systemic applications work well during this time but may be impractical for homeowners with large trees. Systemic insecticides containing imidacloprid or dinotefuran may be applied as a soil drench in spring following elm leaf bud break.

Elm leafminer egg-laying scars on an elm leaf.

— Ryan Davis, Arthropod Diagnostician

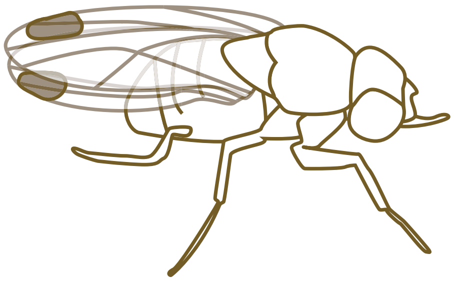
IPM In The News

Monarch Butterfly Decline Linked to Weather and Herbicides

Monarch butterfly populations have declined over the past two decades. Unlike other migratory species, which have distinct summer and winter ranges across one generation, monarchs take multiple generations to travel from Mexico to Canada and back. Therefore, local population levels are linked to events that may happen anywhere during their migration. Biologists at Michigan State University modeled 9 years of weekly, site-specific summer abundance of monarch butterflies at sites across Illinois to assess relative associations of monarch abundance with climate, crop cover, and glyphosate (herbicide) use. The authors found the first evidence that the higher use of glyphosate in 1994-2003 correlated with reduced local adult abundance, and that warmer temperatures in their winter range also resulted in reduced populations.

Princess Pheromone in Ants

Scientists have long studied pheromone communication between adult ants. Recently, entomologists at North Carolina State University published in *Animal Behavior* that they have identified a new communication pheromone released by the ant larvae. Adults of the Indian jumping ant (*Harpegnathos saltator*) can detect whether larvae are developing into a queen based on changes in the chemical compositions of the different wax layers. They coined this the "princess pheromone." The researchers discovered that if a larva gives signs of maturing into a queen at the wrong time, worker ants become aggressive, "harassing" the larva to develop into a worker instead. But the same cues at the right time give the larva access to the colony resources it needs to thrive and develop as a queen. Signals like the princess pheromone are essential for survival of social insects, otherwise, all larvae could develop as queens and their "society" would fall apart. The authors plan to investigate whether the princess pheromone is present in other social insect species.



Improved Spotted Wing Drosophila Lure

The spotted wing drosophila (*Drosophila suzukii*; SWD) is an invasive pest in North America that attacks several fruit-bearing crops. A lure for monitoring SWD populations was developed in 2014 using four chemicals from wine and vinegar: acetic acid, ethanol, acetoin, and methionol. A team of researchers from USDA Agriculture Research Service in Washington, experimented with the chemicals—both their amounts and release rates—to make a more attractive lure. They found that increased amounts of acetic acid, ethanol, and acetoin enhanced the lure's performance, but increased methionol had no effect. In particular, increasing both acetic acid and acetoin resulted in higher attraction than did increasing one of them independently, suggesting that they work together in harmony. The researchers' new lure caught 104% more SWD males and 147% more SWD females than the original formula.

Disruption in Honey Bee Flight

In a study published in *Scientific Reports*, biologists at the University of California (UC) San Diego demonstrated for the first time that the neonicotinoid pesticide, thiamethoxam, can impair honeybees' flight ability. Previous research had shown that foraging honeybees that ingested neonicotinoids were less likely to return to their colony, but the reason was unknown. The UC researchers exposed bees to field-realistic insecticide levels, and measured flight distance, duration, and velocity. Long-term exposure to the pesticide over one to two days reduced the ability of bees to fly. Short-term exposure briefly increased their activity levels, where bees flew farther and more erratically. The authors concluded that bees that fly more erratically for greater distances may decrease their probability of returning home.

Wax Worms as Potential Solution to Plastic Waste

Worldwide, people use approximately one trillion plastic bags each year, and they are very slow to degrade. Researchers in Spain report in *Current Biology* that a common waxworm (*Galleria mellonella*) is able to digest polyethylene plastic. They found that the wax worms were not only ingesting the plastic, they were also chemically transforming the polyethylene into ethylene glycol. Their ability to degrade plastic is most likely related to their ability to consume bees' wax, their normal food source. The authors will continue to explore the molecular details of the process, and someday devise a biotechnological solution to managing polyethylene waste.

Olive a Host for Emerald Ash Borer

Wright State University scientists found that a species of olive tree (*Olea europaea*) can serve as a host for the emerald ash borer. In 2015, the same group discovered that the North American native, white fringetree (*Chionanthus virginicus*), is also susceptible. These two trees are in the Oleaceae family, and account for the only species outside of the genus *Fraxinus*, capable of supporting the emerald ash borer. To test the olive, the researchers used cut stems from field-grown trees, and found that 45% of the larvae that hatched on the branches were recovered from within the wood, either as larvae, pupae, or adults. This percentage is lower than the susceptible ash hosts and higher than the more tolerant ash species, such as Manchurian ash. Future studies on olive will focus on egg-laying rates and growth impacts of larval feeding on field and potted trees.

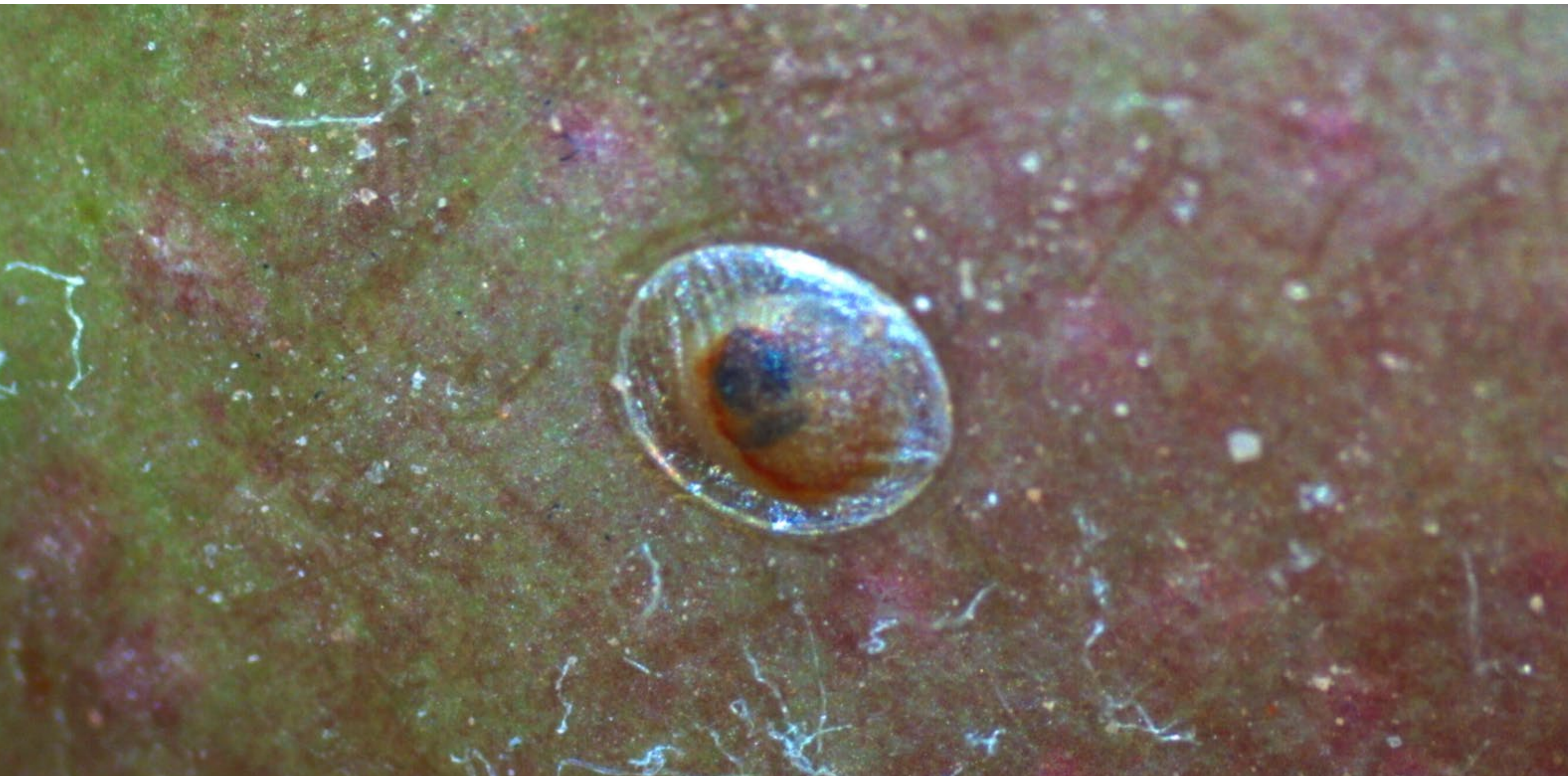
Novel Biopesticide for SWD and Others

Methyl benzoate is a popular ingredient in perfumes, soaps, and shampoos. Some flowers produce it to attract bees for pollination. Many insects also produce it as an attractant, although not all insects are attracted to this compound. A USDA Agriculture Research Service chemist tested methyl benzoate as an environmentally friendly control for spotted wing drosophila (SWD), an invasive species from Asia, and on other crop pests. The chemical was found to not only repel, but kill, SWD. In addition, methyl benzoate was found to be 5 to 20 times more toxic to eggs of brown marmorated stink bug, diamondback moth, and tobacco hornworm than a conventional pyrethroid insecticide. Future studies will test methyl benzoate's effectiveness against fire ants, gypsy moths, stored-product insect pests, mosquitoes, and *Varroa* mites, the number-one problem of managed honeybees today. Many of these insects are developing resistance to standard pesticides.

New Publications, Podcasts, Recordings, and Videos

- USDA recently published Land Use, Land Cover, and Pollinator Health: A Review and Trend Analysis, which reviews the literature on the effects of land use on pollinator health and examines trends in pollinator forage quality land uses and land covers based on changes in U.S. over the last 30 years.
- Increasing Agricultural Sustainability Through Organic Farming outlines research supporting the environmental benefits, including soil health, water quality, biodiversity, and more.
- The University of Minnesota has a new website for Deep Winter Greenhouses, which allow for growing food year-round.

Featured Picture of the Quarter



Codling moth is the primary pest of apples. Females lay a tiny egg on the surface of the fruit, and larvae tunnel in to feed on the seed. This egg is in the late red-ring stage where development of larval features are evident, such as the dark head capsule and prothoracic shield.

——— Photo by Loren Linford and James Withers

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