Small Fruit News

Spring 2023 Edition, Vol. 23 No. 2 www.smallfruits.org

Inside this issue:

Biology and Management of Slugs in Strawberries

Kirsten Brichler and Douglas Pfeiffer

Adjunct Faculty, Southwest Minnesota State University, Marshall MN

Professor of Entomology, Virginia Tech, Blacksburg VA

Most people who have grown strawberries or vegetables in the Southeast have had their experiences with slugs. These pests damage low-growing vegetable tissue and can be difficult to control. Here we will present some general information on this group, whose biological details are poorly known to most.

What is a slug?

Slugs are land-dwelling mollusks that are closely related to snails. The main distinguishing feature that sets slugs apart from snails is their lack of a shell. Slugs are soft-bodied, flexible, and have no legs. They have 2 pairs of feelers on their head – the top pair has eyes, while the lower pair is used for smelling. There is a thickened, saddle-like structure on the dorsal surface called the mantle (Fig. 1); along the edges of the mantle are the genital openings, anus and respiratory openings. They are hermaphroditic animals, meaning that each individual will have male and female organs. This allows nearly any two individuals that meet to be able to mate and reproduce. Simultaneous reciprocal mating is common (Fig. 2). Mated slugs will then lay clutches of eggs that hatch into the next generation (Fig. 3a,b). While the eggs in the images are exposed, in nature, these are laid under stones or other protected areas.

Due to their soft bodies and lack of a protective shell, slugs are highly susceptible to drying out and dying in hot and dry conditions. They are most active during cool and wet times, such as during rainfall and night. Slugs will seek shelter under plant debris and in earthworm burrows during sunny and dry conditions.

Multiple species of slugs are common pests to various food crops and ornamental plants. These species of slugs are considered generalists and will eat a wide variety of plants and fungi. Common species include the gray garden slug (*Deroceras reticulatum*; Fig. 2*),* the marsh slug (*Deroceras leave*; Fig. 4), the dusky slug (*Arion subfuscus),* and the garden slug (*Arion hortensis*; Fig. 1*).* While the exact timing of their life cycles and adult size may differ among these species, they will all consume a variety of plant species.

Fig. 1. Dusky slug, *Arion subfuscus* – note the saddle-like mantle (photo K. Brichler)

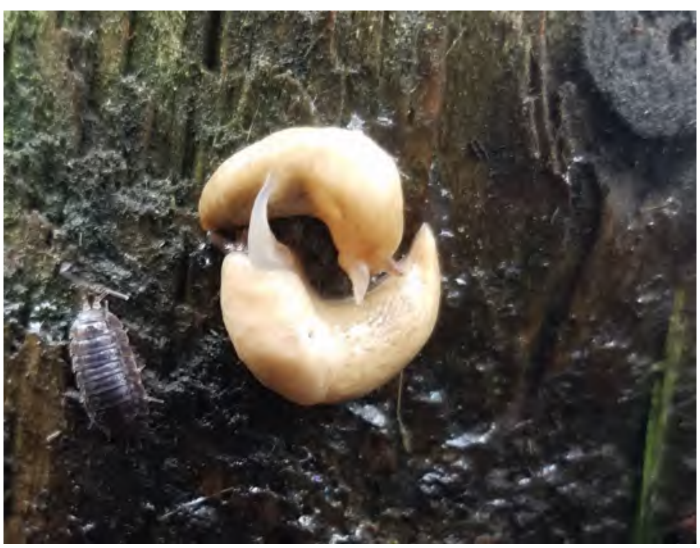

Fig. 2. A pair of hermaphroditic grey garden slugs, *Deroceras reticulatum*, mating. This orientation allows the reproductive openings of each partner to meet. Simultaneous reciprocal mating is common (photo K. Brichler).

Fig. 3a. A slug producing a mass of clear, glistening eggs (photo D. Pfeiffer). 3b. Dusky slug, *Arion subfuscus*, producing an egg mass (photo K. Brichl

er)

Fig. 4. Dark-colored marsh slug, *Deroceras leave* (photo K. Brichler)

What do they do?

Feeding injury by slugs is created when the slug rasps a sandpapery tongue-like organ (the radula) on the surface of a plant. This rasping will leave rough holes in fruits and holes or "window-pane" damage on the leaves of plants (Fig. 5). Small seedlings may be eaten below their growing point and killed, and fruits with slug feeding are unmarketable. Feeding injury also leaves a point of invasion for other pests and diseases.

Fig. 5. "Window-pane" type of injury on corn leaves produced by the rasping radula of a slug caught in the act (photo K. Brichler).

Slugs can be significant pests of fruit crops like strawberries. Low growing plants like strawberries create a shady, moist habitat that protects slugs from sunlight and predators. Soft fruits, especially strawberries, growing close to the ground, provide an ideal food source for slugs that is easily accessed under the protection of the plant's leaves.

How do I know if it's slug damage?

Slugs will leave ragged holes on ripe fruit and occasionally on leaves of strawberry plants (Fig. 6). While slugs may not be present during sunny daytime hours, there will often be shiny slime trails left at the crime scene. Slugs may be found actively feeding if plants are checked in the early morning, late evening, or during cloudy, rainy days.

Fig. 6. Slug injury to strawberries renders fruit unmarketable, allowing entry of rot organisms (photo Ontario Ministry of Agriculture and Food)

Traps can also be set to scout for slugs. This may be as simple as placing a piece of wood or shingle on the ground near plants for a couple days, and flipping it over to count slugs in the early morning. The wood or shingle provides moist shelter that the slugs are attracted to. An alternative trap is a cup or bowl filled with beer or a sugar and yeast solution. Place the bowl in the soil with the rim even with the soil surface. Some of the attracted slugs will slip into the bowl and drown, and be available for counting later.

How do I manage pest slugs?

Slugs can be a notoriously difficult pest to manage. Being mollusks, they are not generally susceptible to insecticides used for many other garden pests. While trapping can be used to monitor slug presence, it generally does not offer enough control for satisfactory management. Check out this YouTube link for an interesting view of beer traps for slugs (https://www.youtube.com/watch?v=cf6FHv5x3sc).

Preventative measures for slugs include removing shelter from the area. Shelter slugs can use includes plant debris, weeds, fallen wood, and rocks. If it is something that creates a moist and cool area on the surface of the ground, slugs will likely use it! An area that has very little shelter and is not over-watered should have a greatly reduced population of slugs.

Certain predators can also help manage slug populations. Multiple species of ground beetles (Family: Carabidae), rove beetles (Family: Staphylinidae), and fireflies (Family: Lampyridae) will consume slugs or slug eggs. Avoiding the use of insecticides that harm ground beetles will allow beetle populations to grow and maintain lower slug populations. Other animals that consume slugs include birds and toads.

Few compounds are approved and effective for use on slugs. These molluscicides are available as baits, often in a granular form. Approved baits include iron phosphate, ferric sodium EDTA, and metaldehyde. Baits will be most effective when used during seasons when slugs are most active, generally in the spring and fall. Care should be taken not to apply water-soluble baits before forecasted rain. Slug bait (especially metaldehyde) is toxic to wildlife, pets, and children. Some formulations of iron phosphate are OMRI-listed and suitable for organic production. Slug recommendations are included in the Southeast Regional Strawberry Integrated Pest Management Guide for Plasticulture Production (https://extension.uga.edu/publications/detail.html?number=AP119-3).

All About Botrytis Fruit Rot

Scott D. Cosseboom and Mengjun Hu

Department of Plant Science and Landscape Architecture, University of Maryland

Botrytis cinerea is a fungus that causes disease in many crops. Most notably, it causes gray mold of strawberry and Botrytis bunch rot of grape (Fig. 1). This pathogen can be spread by wind and rain and can overwinter on leaf debris and fruit mummies. On some fruit like strawberries, the disease has a "latent period," meaning that infection and symptom development happen at different times. On strawberries, infection can occur at bloom, while disease symptoms appear at fruit ripening or post-harvest.

Figure 1. Botrytis fruit rot disease on grape, blackberry, strawberry, and blueberry are examples of the pathogen's broad host range (Photo credit: MyIPM Smartphone App).

However, *B. cinerea* is only able to infect under appropriate weather conditions. Researchers have found that particular combinations of temperature and leaf wetness duration are critical for infection to occur. Disease prediction and spray warning system models are currently available for strawberry gray mold through Agroclimate (Fig. 2; http://www.agroclimate.org/tools/sas). These warning systems have been demonstrated to be effective for triggering preventative fungicide applications. In field trials they triggered fewer fungicide applications than a calendar-based spray program while maintaining an acceptable level of disease control (Hu et al. 2021).

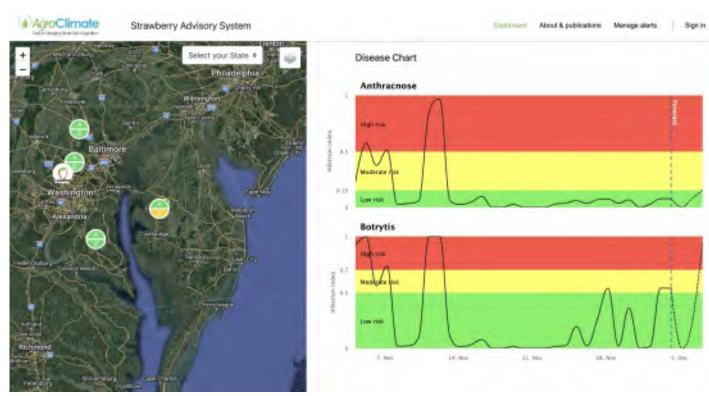

Figure 2. Example of the Agroclimate Strawberry Advisory System website that displays real-time anthracnose and Botrytis fruit rot disease risk, which is based on weather station data.

Cultural methods that reduce humidity or wetness or aid in the drying of the plant canopy tend to be effective in reducing Botrytis fruit rots. In strawberry, not much research has been conducted on cultivar susceptibility to gray mold. However, cultivars with flowers and fruit with an upright stature and with a calyx that grows away from the fruit can more easily dry out, which may reduce disease incidence. In grapes, cultivars with fewer pores on the berry skin and thicker skin are more resistant to Botrytis bunch rot. Also, the use of plastic tunnels and plastic mulch in strawberries and pruning techniques to reduce canopy density around the fruit zone in grapes can reduce the plants' exposure to excess water/humidity, thereby lowering the incidence of gray mold.

The ability of this fungus to cause disease in many crops indicates just how adaptable it can be. It is also adaptable to fungicides, and fungicide-resistant populations have developed worldwide. From 2014 to 2019, we collected Botrytis from strawberries, blackberries, red raspberries, black raspberries, and grapes, and found that fungicide resistance was widespread in each crop. Samples were collected in Maryland and Pennsylvania. We evaluated isolates for their sensitivity to all currently registered conventional fungicides except for the multisite fungicides captan and thiram, to which resistance is not a concern. The isolates were most frequently resistant to the FRAC 1 (e.g., thiophanate-methyl), FRAC 2 (e.g., iprodione), FRAC 9 (e.g., cyprodinil), FRAC 11 (e.g., pyraclostrobin), and FRAC 17 (e.g., fenhexamid) fungicides. The isolates were only sensitive to two fungicide groups, FRAC 7 (e.g., boscalid, penthiopyrad, benzovindiflupyr, pydiflumetofen, and isofetamid) and FRAC 12 (e.g., fludioxonil) (Fig. 3).

The development of resistance has limited the effective options for controlling Botrytis fruit rots. This may lead to increased usage of newer FRAC 7 and FRAC 12 fungicides, which in turn, could exacerbate resistance development. To prevent resistance development, it is important to embrace resistance management techniques. First, spray only when necessary. This can be aided by the implementation of spray warning systems, like those mentioned above. Also, cultivars known to be more resistant to Botrytis may require less fungicide input. Some crops such as grapes have phenology-related susceptibility to Botrytis, meaning that season long fungicide protection is unnecessary. Secondly, base the spray program on the multisite fungicides captan or thiram, or other materials that have low risk for resistance development.

In summary, the fungus *B. cinerea* is a troublesome pathogen in multiple crops including small fruits. Control of Botrytis fruit rot diseases can be aided by both cultural methods that reduce humidity and wetness experienced by the fruit and chemical methods (fungicides). Fungicides can be highly effective for prevention of these diseases, but resistance is a major concern. Good stewardship of the remaining effective fungicides through resistance management strategies may prolong the effective life span of the fungicide products.

Cosseboom, S. D., and Hu, M. 2021. Identification and characterization of fungicide resistance in *Botrytis* populations from small fruit fields in the Mid-Atlantic United States. Plant Dis. doi:10.1094/PDIS-03-20-0487-RE.

Hu, M., Cosseboom, S. D., Schoeneberg, A., Johnson, C. S., Peres, N. A., and Lea-Cox, J. 2021. Validation of the Strawberry Advisory System in the Mid-Atlantic region. Plant Dis. 105:2670–2679.

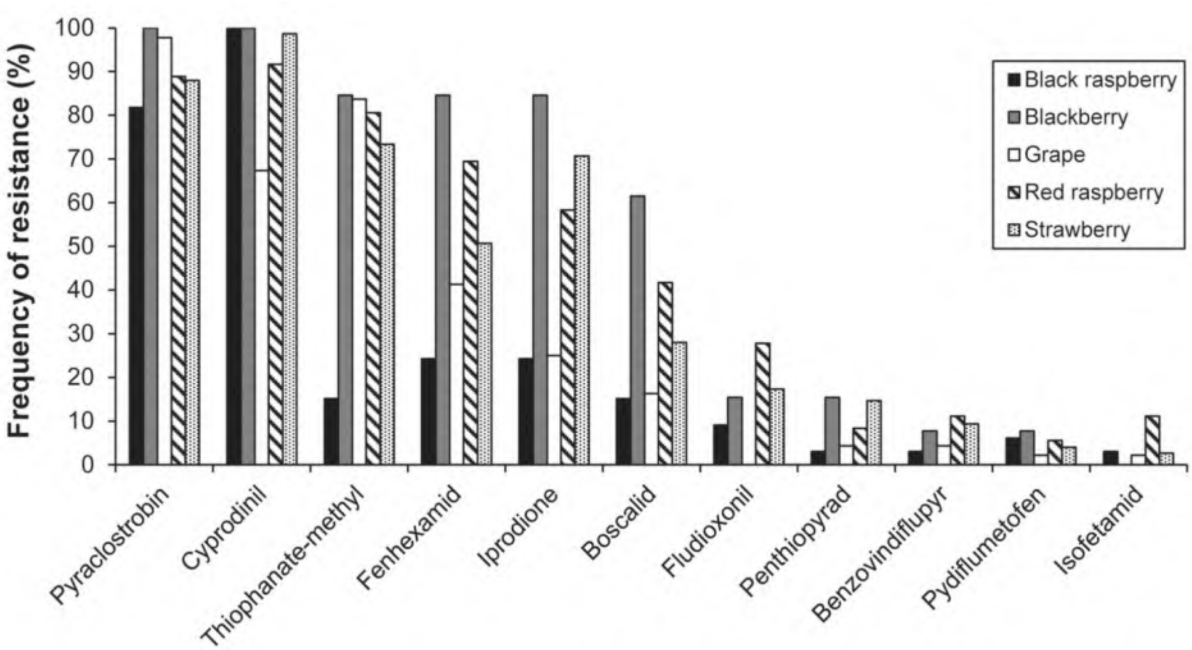

Figure 3. The frequency of isolates that were resistant to eleven fungicides representing seven commonly used fungicide modes of action (FRAC groups) with isolates collected from different small fruit crops (Cosseboom and Hu 2021).

Organic Fungicides – A Review of Recent Blueberry Trials in GA and NC

Bill Cline, North Carolina State University, and Jonathan Oliver, University of Georgia

Organic blueberry production is practiced worldwide with varying degrees of success. In the southeastern U.S. our warm, humid climate is one of the most challenging due to increased pest pressure when compared to drier climates in California and elsewhere. The studies cited here were conducted in North Carolina (2022) and Georgia (2020, 2021, 2022) to determine the efficacy of organic fungicides for controlling blueberry diseases. These diseases (Figs. 1-4) included anthracnose ripe rot (*Colletotrichum* sp.), mummy berry (*Monilinia vaccinii-corymbosi*), Septoria leaf spot (*Septoria albopunctata*), and blueberry leaf rust (*Thekopsora minima*).

Figure 1. Anthracnose fruit rot of blueberry

Figure 2. Mummy berry fruit infection

Figure 3. Septoria leaf spot

Figure 4. Blueberry leaf rust on upper (top) and lower leaf.

What are Organic Fungicides?

Organic fungicides are non-conventional products that are listed by the Organic Materials Review Institute (OMRI) and are generally accepted by organic reviewers as qualifying for use in organic production systems. The products evaluated in these trials (Table 1) include oils, plant or bacterial extracts, or biological control agents (microorganisms) as their active ingredient. Not all products were evaluated in all trials, and not all products were tested against all pathogens. Table 2 gives a summary of the number of times each product was evaluated in the various trials, and against which pathogens.

Table 1. Organic fungicides evaluated on blueberry in Georgia and North Carolina, 2020-2022

Trade Name	Active Ingredient
Actinovate AG	*Streptomyces lydicus* WYEC 108
Double Nickel LC	*Bacillus amyloliquefacens* strain D747
Ecoswing	Extract of *Swinglea glutinosa*
Howler	*Pseudomonas chlororaphis* strain AFS009
LifeGard WG	*Bacillus mycoides* isolate J
OSO 5% SC	Polyoxin D zinc salt
Oxidate 5.0	Hydrogen peroxide 27%, peroxyacetic acid 5%
PureSpray Green	Mineral oil
Serenade Opti	QST 713 strain of *Bacillus subtilis*
Theia	*Bacillus subtilis* strain AFS032321
Thyme Guard	Thyme oil 23%
Timorex Act	Tea tree oil

Testing Methods:

Fungicides were evaluated under field conditions in randomized, replicated trials using CO_2 backpack sprayers applying the equivalent of 50, 75 or 100 gallons of spray solution per acre. Products were applied repeatedly every 7-14 days from bud break through late bloom, except for the NC leafspot trials, where products were applied at two-week intervals five times after harvest. Mummy berry primary (shoot strike) stage and secondary (fruit infection) stage were evaluated in the field based on visible symptoms. Fruit rot diseases were evaluated by hand harvest of ripe fruit every seven days for two pickings. Harvested berries were held at room temperature for 48-72 hours, then sorted and evaluated based on the presence of characteristic symptoms (spores, mold, soft or leaky fruit). Leaf spot and leaf rust data consisted of incidence ratings (number of leaves infected), severity (number of spots per leaf), defoliation, and in the case of leaf rust in NC on the cultivar Vernon, a visual estimation of bud set as an indicator of early defoliation, since bushes that defoliate prematurely produce fewer flower buds for the next year's crop. All data were subjected to statistical analysis. All trials included an untreated control. Exact dates, locations, and results for each trial are available in the references cited at the end of this article.

Results:

Table 2 (page 8) shows a summary of results from the seven organic fungicide trials compiled in this review article.

Discussion:

Organic fungicides are not as consistently effective as conventional fungicides, but in many cases the organic products performed significantly better than the untreated control, as shown by the multiple "+" symbols in Table 2. In some instances, both the "+" and the "-" symbol appear in the same cell, indicating that the product worked in some trials but not in others. Often the failure of control occurred under a high disease pressure, whereas control was achieved when disease pressure was light. Products that have one or more "+" symbols in the table are those that organic growers might consider for use against that pathogen. Many cells in the above table contain only the "o" symbol. These are experiments that need to be conducted in the future (or results sourced from prior work) in order to fill out the blanks and provide organic growers with the information needed to make good disease control decisions. This review article is limited in scope to the seven trials conducted in a three-year period in Georgia and North Carolina, however these experiments provide real-world results in a very challenging disease control environment and should be useful as guidance to growers in the southeastern US and elsewhere.

References:

Oliver, J.E., Cline, W.O. and Curry, S. 2022. Evaluating organic fungicides for control of blueberry diseases in the southeastern U.S. Research report to the Southern Region Small Fruit Consortium. https://smallfruits.org/files/2022/12/2022-R-02-2022-R-03-Final.pdf

Oliver, J.E., 2022. Evaluation of fungicides for organic disease control in 2020 & 2021. Dixie Blueberry News, 11 March 2022.

Table 2. Summary of seven organic fungicide trials in Georgia and North Carolina, 2020-2022.
"o" = not tested, "-" = not effective, "+" = significant disease control (as compared to the untreated check). Multiple symbols in a cell indicate the number of times a product was evaluated against that pathogen over the three years.

Product and rate/acre	Number of trials	Mummy Berry	Anthracnose fruit rot	All fruit rots combined	Septoria leaf spot	Blueberry rust
Actinovate AG 12 oz	1	-	o	o	o	-
Double Nickel LC 4.5 pt	6	-	- -	- +	- +	- - - -
Ecoswing 1.5 pt	1	+	o	o	o	o
Ecoswing 2 pt	2	+	o	o	o	-
Howler 3 lb	1	-	o	o	o	-
Howler 5 lb	6	- +	- -	+ +	- +	- + -
LifeGard WG 2.5 oz	2	-	o	o	o	- -
OSO 5% SC 6.5 fl oz	5	-	+	+	- +	- - - -
Oxidate 5.0 26 fl oz	1	-	o	o	o	-
PureSpray Green 1.5 gal*	5	o	+ +*	- -	- +	- + +
Serenade Opti 20 oz	5	- +	-	-	-	- - -
Theia 3 lb	3	+	-	-	+	+
Thyme Guard 1.5 qt	3	o	-	+	- -	- - -
Timorex ACT 17 fl oz	3	o	-	+	-	- -
Conventional fungicides**	7	+	++	++	+++	+++

*PureSpray Green was effective against anthracnose fruit rot but also caused unacceptable darkening at the calyx end of 'Farthing' berries in the NC trial, and for that reason is not recommended for pre-harvest use.
**Various products with known efficacy against specific diseases were used in some trials for comparison as a "conventional control", including Cevya, Indar 2F, Orbit 3.6E, Miravis Prime, and pyraziflumid.

Climbing cutworms in grape vineyards

Douglas G. Pfeiffer, Dept. of Entomology, Virginia Tech

Many grape growers have had the experience of finding primary buds on their vines destroyed, leaving behind ragged remnants. During the day, the culprits may not be seen on the aerial parts of the vine. By looking under clods of soil, stones, or in killed sod, one may find caterpillars tightly curled in hiding (Fig. 1). These climbing cutworms are sporadic vineyard pests, mainly in sites with sandy soils, where they may completely strip the buds and young shoots in the early spring.

Fig. 1. A climbing cutworm caterpillar in its typical tightly curled pose when taken from its day time shelter.

There are many species of cutworms that are found on many different crops. Climbing cutworms can be found on grape, apple, peach, pear, and plum. Ash, boxelder, birch, boxelder, maple and other species are also fed upon. Several species, known as the climbing cutworms, tend to climb grapevines and fruit trees in spring and feed on the buds and young foliage. The large larvae cause similar kinds of injury and the robust adult moths of each species are similar in appearance to each other. At least 10 species of climbing cutworms cause damage to fruit trees in the eastern U.S. and Canada, but six species are the most common and widely distributed: Dingy cutworm, *Feltia faculifera* (Guenee), spotted cutworm, *Xestia c-nigrum* (L.), darksided cutworm, *Euxoa messoria* (Harris), variegated cutworm, *Peridroma saucia* (Hubner), mottled cutworm, *Abagrotis alternata* (Grote), and W-marked cutworm, *Spaelotis clandestina* (Harris).

Appearance: The larvae of climbing cutworms are large, smooth caterpillars, measuring 1.2 to 1.6 inches (30 to 40 mm) when fully grown. The body has only a few hairs and the head capsule is usually brown or black; some have unusual markings on the head. Larvae of the different species vary in color with most species having a dull gray-brown background color with various species having stripes, spots, or marked with dark brown, black, yellow and white splotches. The dark brown pupae resemble those of leafrollers, but are much larger in size [i.e. >0.8 inch (20 mm)]. The adults are dark brown or grayish colored moths that look quite similar and have wingspans of about an inch (25 mm).

Life cycle: The biology of the various climbing cutworms varies considerably but the peak flight periods and generations for some of the common species are listed above. The most common species have one or two generations per year and overwinter as half-grown larvae on the soil in leaf litter and orchard debris. A few other species overwinter as eggs or even as adults. The species which overwinter as larvae begin to become active as the weather warms, generally in mid-April. This group of moths derives its name from the larval habit of climbing trees to feed on buds and young foliage during the night, and then crawling back down to the ground to seek shelter under leaf litter, killed grass, or debris on the vineyard floor during the day (Fig. 2). The larvae often curl up tightly when disturbed. Hundreds of larvae may feed on a single tree. The larvae mature by May and enter the soil to construct pupal chambers. In two-generation species, second generation feeding is minor.

Fig. 2. Killed sod habitat where larval climbing cutworms were hiding.

Adult emergence varies among species as shown above, but the most common species are on the wing from June through September. Eggs are laid on leaves, twigs, bark or even grasses. Newly hatched larvae of the single generation species seek low vegetation on which to feed until fall when they move to the ground seeking overwintering sites. Species with multiple generations per year generally overwinter as eggs.

Injury: Most injury from climbing cutworms occurs in the spring when they feed on primary buds or young shoots. In severe cases, all buds may be killed, so that growth is delayed considerably (Fig. 3a), compared to uninjured cordons (Fig. 3b). While growth will likely resume later from secondary or tertiary buds, yield from such shoots is reduced, and harvest maturity is erratic, especially when considering bunches produced on other, uninjured vines.

Fig 3a. Destroyed primary buds in a vine infested with climbing cutworms. 3b. Shoot growth on vines with undamaged buds in the same vineyard block.

Another pest, grape flea beetle, will destroy primary buds, but injury by this species is mainly in rows nearest woods. There is overlap in the appearance of damaged buds, though flea beetle injury is often a symmetrical round hole into the side of the bud, with contents hollowed out.

Monitoring: The best way to monitor is to examine buds at bud swell for signs of first feeding early in the spring. This should be done frequently (every couple of days from the beginning of bud swell until 2-3 inches of shoot growth; also, check the leaf litter around the base of the tree for overwintering larvae. Examine sites on the ground for rolled up larvae (under clods of earth, etc.). The larvae can only be observed feeding in the trees at night. Black light traps readily capture the adults, but because of the many host plant species and similar looking nonpest species, it is usually not an effective way to monitor. Because of the sporadic nature of this pest complex, thresholds have not been established.

Control: Several insecticides may be used for control of climbing cutworms, at bud swell of grapevines. Altacor (chlorantraniliprole), Delegate (spinetoram) and Entrust (spinosad) work well and their selectivity supports other aspects of IPM. The pyrethroids Mustang Maxx (zeta-cypermethrin), Brigade (bifenthrin), Baythroid XL (beta-cyfluthrin) also work, but are more disruptive to biological control programs. More information on chemical control of climbing cutworms is provided in the bud swell period in the Southern Region bunch grape recommendations (https://smallfruits.org/ipm-production-guides/).

Orondis Gold for Phytophthora Crown and Root Rot Management in Strawberry

Mary Helen Ferguson – Louisiana State University Agricultural Center

Guido Schnabel – Clemson University

Orondis Gold, a fungicide containing the active ingredients oxathiapiprolin and mefenoxam, is now labeled for strawberries for managing Phytophthora crown rot (vascular collapse) and red stele root rot.

This gives you, the grower, an option for Phytophthora root and crown rot management, in addition to mefenoxam or metalaxyl alone (Fungicide Resistance Action Committee [FRAC] code 4; Ridomil Gold SL, Ultra Flourish, MetaStar 2E, and others) and the phosphonate chemicals (FRAC code P07; aluminum tris, phosphorus acids and salts).

Oxathiapiprolin (FRAC code 49) is a welcome addition to existing chemical options in the toolbox for Phytophthora root and crown rot management, especially considering that resistance to FRAC 4s such as mefenoxam has been found in the strawberry crown rot pathogen (*Phytophthora cactorum*) on some farms.

It is critical to use good resistance management practices to reduce the likelihood that *Phytophthora* populations will develop resistance to this new mode of action, as well as to preserve existing effectiveness of mefenoxam and metalaxyl. Management of Phytophthora crown and root rot should begin with good cultural practices. These include practicing crop rotation, providing good drainage, and obtaining clean plants from reputable sources. Overhead irrigation is essential for establishing bare-root plants especially, and insufficient water during establishment stresses plants, which may result in increased disease susceptibility. At the same time, excessive water favors Phytophthora diseases, so water should be managed carefully. Water source should be considered. Surface water from ponds that collect runoff from fields may be contaminated with *Phytophthora*. Irrigation with well-water is preferable. Cultivars commonly used in the southeastern United States are susceptible to *Phytophthora*, but keep an eye out for new ones with increased resistance. Application of a mefenoxam/metalaxyl or phosphonate product, or now Orondis Gold, is a measure to take where problems with Phytophthora crown or root rot are anticipated.

Table 1 compares Orondis Gold and a commonly available mefenoxam product, Ridomil Gold SL.

Table 1. Comparison of Orondis Gold and Ridomil Gold S

	Orondis Gold	Ridomil Gold SL
Active ingredient(s) (concentration; FRAC code)	Mefenoxam (9.89%, 0.88 lb/gal; FRAC 4) and oxathiapiprolin (3.29%, 0.29 lb/gal; FRAC 49)	Mefenoxam (45.3%, 4 lb/gal; FRAC 4)
Application rate	20 to 62 fluid ounces per acre	1 pint per acre (adjust for root zone width/width of band)
Amount of mefenoxam per acre per application	0.14 to 0.43 lb	0.5 lb (adjust for root zone width/width of band)
Maximum product usage per acre per year (amount of mefenoxam in this amount)	124 fluid ounces (0.85 lb mefenoxam)	3 applications / 3 pints (1.5 lb mefenoxam)
Maximum allowed mefenoxam per acre per year	1.5 lb (soil-applied) or 0.19 lb (foliar/soil-directed)	1.5 lb
Minimum time between applications	30 days	30 days
Timing instructions for annual strawberry plantings	"Make the first application soon after planting when overhead watering for plant establishment has been completed, and a second application 30 days before the beginning of harvest or at fruit set."	"Make the first application after transplanting. Make the second application 30 days before the beginning of harvest or at fruit set. Apply the third application during harvest, depending on disease pressure and environmental conditions."
Application method(s) allowed	Through drip irrigation system only	Through drip irrigation system or banded/ground-applied*
Pre-harvest interval	28 days	0 days
Re-entry interval	48 hours	48 hours if banded/ground-applied; 0 hours if applied through drip irrigation

*Application by overhead chemigation is also allowed, but this is not a common practice in the southeastern US.

So now what? Do I always have to chemically treat for *Phytophthora*? Should I use Ridomil Gold SL or Orondis Gold? If I use Orondis Gold, should I use the low rate or the high rate, and why is there such a big rate range anyway? Those are all very good questions, and we are trying to answer them to the best of our abilities.

First of all, if there is no problem then there is no need for action. If your soil is well drained, you have had no history of *Phytophthora* problems, and there is no word from the nursery that the plants are contaminated, then don't waste your money and don't stress your plants and the environment with unnecessary chemical applications. But if you do have good reasons to suspect there will be a problem, then protect your crop.

From an effectiveness perspective, either Orondis Gold or a mefenoxam/metalaxyl-only product such as Ridomil Gold SL is expected to have very good efficacy against Phytophthora crown and root rots, as long as there is no resistance to mefenoxam in the pathogen population. In general, fungicide mixtures are better able to prevent the emergence of resistance than products with a single mode of action, if no resistance to either active ingredient exists in the field. That is because pathogens develop resistance to active ingredients consecutively over time, often altering one target gene first and then taking a bit of a break (to generate more genetic diversity) before altering a second target gene to become resistant to two active ingredients. Pathogens will have a much harder time developing two different resistance mechanisms at the same time. With that in mind, Orondis Gold is to be favored over Ridomil Gold SL for resistance management reasons unless you mix Ridomil Gold SL with something else, such as a phosphonate product (e.g., ProPhyt). Alternatively, Ridomil Gold SL could be used in rotation with ProPhyt or similar products.

If used at the highest labeled rate, Orondis Gold can be used twice per year. Using the 28 fluid ounces per acre rate (or another rate between 20 and 41 fluid ounces per acre) will allow for a third application. However, Orondis Gold has a 28-day pre-harvest interval, limiting its utility later in the season. If more than two applications of Orondis Gold are made, a product with a different mode of action (e.g., a phosphorous acid salt) must be used before a third application.

It is possible to legally make one Ridomil Gold SL application even after Orondis Gold use is exhausted. That is because the maximum yearly amount of Orondis Gold contains 0.85 pound mefenoxam, and 1.5 pounds of mefenoxam are allowed per acre annually. Keep in mind that repeated use of mefenoxam poses great selection pressure on the pathogen population and increases the risk of resistance development. Thus, a product with a different mode of action (phosphorus acid salts) should still be used before a third application of a mefenoxam-containing product.

To our knowledge, no field resistance to oxathiapiprolin in the Phytophthora crown rot or red stele root rot pathogens (*P. cactorum and P. fragariae*, respectively) has been reported at this time. However, we need to use this product with caution because the risk of resistance development to oxathiapiprolin is considered medium to high, according to FRAC.

Information in this article is based on label language at the time of writing. Read the label of the product you have carefully for updates and additional information. Reference to commercial or trade names is made for the reader's convenience and with the understanding that no discrimination nor endorsement of a particular product is intended.

Strawberry sap beetle, a strawberry pest approaching harvest

Douglas G. Pfeiffer and Jayesh B. Samtani,

Virginia Tech Dept. of Entomology, Blacksburg and Hampton Roads Agric. Res. and Ext. Center, Virginia Beach VA

Many people are familiar with sap or picnic beetles in the family Nitidulidae (*Carpophilus* sp.). Small black (about 6 mm), oval-shaped beetles with clubbed antennae and short elytra or front wings are sometimes seen in tips of corn ears that are previously damaged by other agents, e.g. corn earworm. Many species of sap beetles feed on overripe or rotting plant tissue. A less commonly seen species to most is the strawberry sap beetle, *Stelidnota geminata* (Say). This is one variety of sap beetles that may occur in strawberry plantings (Potter et al., 2013).

The adult strawberry sap beetle (Fig. 1) is about half the size of the picnic beetle in corn ears, about 3 mm. It is a dark mottled reddish brown, rather than the black appearance of *Carpophilus* spp. Its elytra are not truncated as in *Carpophilus* but extend to the end of the abdomen. The pronotum (the section of the thorax just behind the head and ahead of the wings) has edges that are flattened, giving a somewhat flared appearance. Larvae are slender grubs with a brown head capsule (Fig. 2). Both adults and larvae may cause injury of ripe and overripe strawberries Fig 3).

Fig. 1. Adult strawberry sap beetle. Note clubbed antennae, flattened edges of pronotum, reddish brown color, and clubbed (knobbed) antennae. (iNaturalist)

Fig. 2. Strawberry sap beetle larva (Univ. Florida)

Fig. 3. Fruit injury by strawberry sap beetle (Ontario Ministry of Agriculture)

Strawberry sap beetle overwinters in leaf litter in woods. While not typically overwintering in strawberry, it does overwinter in blueberry and raspberry plantings (Loughner et al. 2007b). Beetles fly into strawberry beds, sometimes from considerable distances (Loughner et al. 2007a). Strawberry sap beetle is most common in wooded settings early and late in the season, favoring agricultural settings during the summer (Blackmer and Phelan 1995).

Injury: Round deep holes are eaten into the sides of ripe and over-ripe strawberries. Fruit is more likely to be fed upon when in contact with the soil, relative to berries higher in the canopy (Rhainds and English-Loeb 2002). However, injury sometimes occurs in berries off the ground as well (Loughner et al. 2008).

Management: Cultural control: Berries should be harvested frequently when they are ripe and before becoming over-ripe. Infestations are more severe later in the harvest season when day-time temperatures are on rise and particularly following rain events. Infestations may be more severe in pick-your-own operations where customers leave fruit behind. Clean-up picking should follow the public picking operation. Baited traps are sometimes recommended for mass-trapping strawberry sap beetles. Baits can include various plant products that emit a fermenting or rotting odor. Whole wheat bread dough was used by Rhainds and English-Loeb (2002). Ripe strawberries can be an effective bait for sap beetles infesting strawberries (Fornari et al. 2013). One trapping study found that traps along the periphery resulted in higher sap beetles numbers in the planting (Rhainds and English-Loeb 2002), so if used, traps should be placed away from the bed. Baited fruits should be discarded off-site. Good management of rots and fungal diseases will lower the incidence of strawberry sap beetle injury, since the beetles are attracted to rotting fruit (Swett et al. 2020).

Chemical control: Since strawberry sap beetle attacks ripe fruit, preharvest intervals should be considered closely if chemical control is desired. Pyrethroid sprays have been effective against strawberry sap beetle. This class is disruptive by way of secondary pest outbreaks, in particular, spider mites. Rhainds and English-Loeb (2002) reported that fenpropathrin (Danitol; PHI = 3 days) effectively reduced sap beetle injury when applied at dusk or mid-day, between appearance of first ripe berries and first harvest. A more selective material, novaluron (Rimon, PHI -= 1 day), is recommended in our southeast regional publication (Melanson et al. 2022). Though beetles fly in from outside the strawberry bed, border sprays may not provide benefit (Loughner et al. 2008).

Biological control: Young larvae of strawberry sap beetle larvae (among other nitidulids) is controlled by the parasitoid *Brachyserphus abruptus* (Say) (Williams et al. 1992). Entomopathogenic nematodes that are potential sources of mortality of soil-dwelling stages of strawberry sap beetles were mentioned by Rondon et al. (2011). Natural enemies attacking strawberry sap beetle may be favored by wildflower strips near the bed (McCabe et al. 2017).

References

Blackmer, J. L., and P. L. Phelan. 1995. Ecological analyses of Nitidulidae: seasonal occurrence, host choice and habitat preference. J. Appl. Entomol. 119: 321-329.

Fornari, R. A., R. Machota, D. Bernardi, M. Botton, and P. L. Pastori. 2013. Evaluation of damage, food attractivts and population dynamics of strawberry sap beetle. Hortic. Bras. 31: 380-385.

Loughner, R. L., G. M. Loeb, and W. W. Turechek. 2007a Strawberry sap beetle (Coleoptera: Nitidulidae) distribution in New York and differential movement in two types of habitat. J. Entomol. Sci. 42: 603-609.

Loughner, R. L., G. M. Loeb, K. Demchak, and S. Schloemann. 2007b. Evaluation of strawberry sap beetle (Coleoptera: Nitidulidae) use of habitats surrounding strawberry plantings as food resources and overwintering sites. Environmental Entomol. 36: 1059–1065.**Loughner, R., G. M. Loeb, S. Schloemann, and K. Demchak. 2008.** Evaluation of cultural practices for potential to control strawberry sap beetle (Coleoptera: Nitidulidae). J. Econ. Entomol. 101: 850-858.

McCabe, E., G. Loeb, and H. Grab. 2017. Responses of crop pests and natural enemies to wildflower borders depens on fnctional grop. Insects 8:(3): 1-8.

Melanson, R., G. Schnabel, P. Brannen, M. H. Ferguson, J. Desaeger, B. Cline, I. Tzanetakis, R. Singh, N. Gauthier, J. Samtani, K. Fontenot, A. Sial, F. Hale, D. Pfeiffer, A. Cato, M. Favre, D. Lockwood, M. T. Mengak, and K. Jennings. 2022. 2022 Southeast Regional Strawberry Integrated Pest Management Guide for Plasticulture Production. Univ. Ga. Extension Pub. 119-3. 74 p. (https://extension.uga.edu/publications/detail.html?number=AP119-3)

Potter, M. A., J. F. Price, D. H. Habeck, D. J. Schuster, and E. McCord. 2013. A survey of sap beetles (Coleoptera: Nitidulidae) in strawberry fields in West Central Florida. Fla. Entomol. 96: 1188-1189.

Rhainds, M., and G. English-Loeb. 2002. Impact of insecticide application and mass trapping on infestation by strawberry sap beetles (Coleoptera: Nitidulidae). J. Entomol. Sci. 37: 300-307.

Rondon, S. I., J. F. Price, D. J. Cantliffe, and J. M. Renkema. 2011. Sap beetle (Coleoptera: Nitidulidae) management in strawberries. Univ. Fla. Extension. HS991. 4 pp.

Swett, C. L., B. B. Butler, N. A. Peres, E. E. Koivunen, E. M. Hellman and J. R. Beaulieu. 2020. Using model-based fungicide programing to effectively control botrytis and anthracnose fruit rots in mid-Atlantic strweberry field and co-manage strawberry sap beelt (*Stelidnota geminate* [sic]). Crop Protect. 124: 105175,10 p.

Williams, R. N., D. S. Fickle, and J. R. Galford. 1992. Biological studies of *Brachyserphus abruptus* [Hym.: Proctotrupidae], a nitidulid parasite. Entomophaga. 37:91-98

Tolerance of southern highbush blueberry to 2,4-D choline postemergence-directed

Kira Sims, Katie Jennings, David Monks, David Jordan, Mark Hoffman, Wayne Mitchem

The 2,4-D choline (Embed Extra) formulation was recently registered for use in bearing blueberry (Anonymous 2021). Annual and perennial broadleaf weeds common to blueberry production are effectively controlled by 2,4-D, including annual morningglory (*Ipomoea* spp.), common lambsquarters (*Chenopodium album* L.), curly dock (*Rumex crispus* L.), field bindweed (*Convolvulus arvensis* L.), Canada goldenrod (*Solidago canadensis* L.), horseweed (*Erigeron canadensis* L.), and vetch species (*Vicia* spp.) (Anonymous 2021).

Therefore, field studies were conducted on southern highbush blueberry (*Vaccinium corymbosum* L.) in Elizabethtown and Rocky Point, NC in 2019, 2020, and 2021 to determine tolerance of younger and older bearing blueberry bushes to 2,4-D choline POST-directed.

Treatments included 2,4-D choline at 0, 1.0, 2.0, 3.0, and 4.0 pt/A applied alone in winter during dormancy, and sequential treatments at 1.0 followed by (fb) 1.0, 2.0 fb 2.0, 3.0 fb 3.0, or 4.0 fb 4.0 pt/A. The first application of the sequential treatments was applied in winter followed by another application of the same amount in spring during early green fruit.

Injury to blueberry from 2,4-D choline treatments was not observed for either maturity stage, and fruit yield was not affected by any of the treatments. Differences among treatments were not observed for fruit soluble solid content (SSC) in older bushes, or for fruit pH, SSC, and titratable acidity (TA) in younger bushes. In older bushes, fruit pH and TA had rate by timing interactions, and TA had a farm-year interaction with differences at Rocky Point in 2019 and Elizabethtown in 2020, but biologically no pattern was observed from the treatments.

These results indicate that 2,4-D choline directed to the base of younger and older bearing blueberry bushes does not affect crop growth, fruit yield or fruit quality when applied sequentially in winter and spring. Because blueberry is a perennial crop, future research should include a multi-year study looking at the effects of 2,4-D choline when applied in sequential years on growth, fruit yield and fruit quality.

For more information please see the full article. Sims K, Jennings K, Monks D, Mitchem W, Jordan D, Hoffmann M. (2022) Tolerance of southern highbush blueberry to 2,4-D choline postemergence-directed. Weed Technol 36(3), 409-413. doi:10.1017/wet.2022.33

Figure 1A. Older blueberry bushes 2 wk after treatment (WAT) in winter in Rocky Point, NC in 2020.

Figure 1B. Younger blueberry bushes 2 WAT in spring in Elizabethtown, NC in 2021.

Next issue of the Small Fruit News: July 2023

Small Fruit News Editorial Team

Weed Science, Chief Editor: **Jayesh Samtani,** Entomology**: Doug Pfeiffer**

Horticulture/Production: **Edgar Vinson,** Plant Pathology**: Mary Helen Ferguson**