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# Stopping Weevil Deeds

***Black vine weevil plagues a number of container nurseries. However, understanding the insect's biology, when combined with cultural, chemical and biological control methods, can help professionals develop a program to manage this pest.***

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The black vine weevil (*Otiorhynchus sulcatus*) is a serious pest of container-grown ornamental plants. And although most everyone agrees with this assessment of the problem, very few nurseries want to admit they have a black vine weevil population to contend with thanks to the negative stigma associated with the insect. Infested shipments are rejected and cost nursery operations time and money. But don't worry, all is not lost. If, as an industry, we can begin to understand this adversary, we can become the hunters instead of the hunted.

**Weevil Biology.** When developing a pest-management program, nursery professionals must consider the unique biology of the black vine weevil. A basic understanding of weevil biology — when combined with a monitoring program, proper cultural practices and timely chemical and biological control measures — can help nursery professionals successfully manage this pest.

Current management options include: host-plant resistance, conventional insecticides targeted against adults, conventional insecticides targeted against larvae, adult-weevil exclusion and biological control agents targeted against larvae. There is a long history of insecticides developed to target larvae and adults, and the proper use of chemicals can be a successful tool for managing black vine weevil. However, chemical use can result in secondary pest outbreaks, limit access to plants due to re-entry intervals and cause potential harm to the environment. Cultural control measures and biological control agents, though perhaps not as common, can also yield promising results.

The black vine weevil is thought to have a northern European origin. It was first recorded in North America in 1835 and was a noted pest in Missouri by 1871. Both larvae and adults are polyphagous and feed on a wide array of plants (more than 100 species). Adults are nocturnal and cause mainly aesthetic damage by feeding on and notching leaves. Conversely, larvae cause significant root damage and may girdle plants if populations are high. Early instars (the larval stage) begin feeding on small roots, while later instars feed on larger roots — especially on the phloem and cambium tissues near the soil surface.

Adults are parthenogenic (only females are known) and, therefore, do not need to mate to lay eggs. This means a single weevil can potentially be responsible for the infestation of an entire nursery. Each adult can lay approximately 200 to 1,000

Adult black vine weevils appear in spring. The modified front wings, called the elytra, are fused, preventing the insect from flying.

eggs, depending on the host plants she has fed on. Glandular scales of lepidote rhododendrons, for example, have been implicated in functioning in a plant's defense against adult leaf feeding because the scales of the plant contain essential oils that can inhibit this activity.

Adult black vine weevils are typical of other weevils in that their heads are elongated into a snout. They measure 8 millimeters (mm) to10 mm long and are jet black, with golden-metallic patches of elongated hair — as well as beads arranged lengthwise in rows — on the elytra (the modified front wings, which cover the back of the insect). The elytra are fused, preventing the insect from flying. The adults are often disguised by soil that clings to them, making it hard to discern them on the soil surface or in leaf litter.

Adult weevils appear in spring. They are awkward, move slowly when walking and often play dead when disturbed. Callow adults have a nonmelanized cuticle that is soft and light-colored and emerge from pupae in the soil. Over a period of six to10 days, while still in the soil, callow adults change in color from white to brown, then finally black. Melanized adults have a hard, black cuticle and immediately feed on foliage after emerging from the soil. The egg laying (oviposition) maturation period for this pest is 20 to 40 days, during which it feeds on leaves before its reproductive system matures. This preoviposition period is the ideal time for applying insecticides. Currently, there are no biological control agents available for controlling adult populations.

**Weevil Identification.** Location and identification of larvae are also important when developing a program to manage black vine weevils. Adults deposit eggs in late spring to early summer on the soil surface or in crevices. As eggs hatch, larvae move down into the soil and begin feeding on small roots, moving to larger roots as the pests mature. Larvae are generally white but can have a yellow to pink cast. The larvae have a tan head capsule and generally hold themselves in a crescent shape. Additionally, they are legless, making it easy to distinguish them from the six-legged larvae of the oriental and Japanese beetle. Black vine weevil has a single generation per growing season, and larvae mature through six to seven instars. The pest is often discovered in poorly performing plants during the last instar stage, when it is overwintering.

Last instars can often be located in late fall to early spring by pulling away the surface soil around the crown of the plant. Nursery professionals who suspect their container-grown plants may be infested with late instars can also use acoustics to detect larval feeding. The use of acoustic technology, while still being perfected for the nursery industry, may allow growers to treat only those pots that are infested, thereby dramatically reducing control costs.

**Monitoring and Controlling Adults.** There are several factors growers must consider before implementing a spray program. To successfully control adult black vine weevils, spraying must be initiated before the insect begins laying eggs. Because adult emergence can occur over several weeks, black vine weevils can migrate to your operation throughout the growing season. In regions of the country with mild winters, a proportion of the previous year's weevil population can survive winter as adults and begin to lay eggs much sooner than the current year's generation. Therefore, it is important the presence of any overwintering adults, as well as the emergence of the current year's generation of weevils, be closely monitored.

Professionals commonly monitor adult populations by placing grooved boards throughout the nursery, frequently flipping them over and checking for adult weevils. Some growers simply turn over pots in the can yard, looking for adult weevils hiding during the day. Another technique involves using pitfall traps. These consist of a 12- to 16-ounce plastic cup buried in the soil until the top of the cup is flush with the soil surface. A second cup is then inserted into the first, making sure to keep the soil flush with the tops of both cups. The inside band (approximately the top 1 inch) of the inside cup is coated with a lubricant to prevent insects that have fallen into the trap from crawling out. To stop the trap from filling with irrigation or rainwater, one-sixteenth-inch holes can be drilled into the bottom of both cups, allowing water to drain, yet keeping weevils from escaping.

There are ways to detect the presence of black vine weevils without trapping them, however. Leaf notching is a telltale sign of adult pest activity at the nursery and signals preovipositional feeding in spring. If the notching can be tolerated, applying insecticide two to three weeks after the emergence of the first adult allows more adults to be targeted with the first spray. Care should be taken when using notching as the sole means of diagnosing black vine weevil activity, as mechanical damage or feeding by other insects might also produce this effect. Adult emergence lasts for several weeks, and multiple insecticide applications are required. Also, because adult weevils are nocturnal, insecticides must be applied in the evening — from a few hours after dusk until dawn — for the greatest control.

**Cultural Control.** Poor nursery production practices encourage black vine weevil infestation and often exacerbate the problem. Proper sanitation can go a long way in mitigating a black vine weevil population. Vigilantly practicing proper cultural controls, both inside and outside the nursery and surrounding areas, prevents pest populations from increasing to unmanageable levels.

The first step is preventing infested stock from entering your operation. All plant shipments received should be carefully inspected for both larvae and adults.

Of course, the same care should be given to plants being shipped from the nursery. The longer you keep plants, the greater the chance for infestation. Material that is not sold when scheduled should be monitored very closely or discarded. The potential for weevil infestation and population buildup is of particular concern to container nurseries growing large-specimen plants that are maintained on-site for several years.

Many nurseries are surrounded by areas that can serve as natural reservoirs for black vine weevils, including hedgerows, windbreaks and neighboring landscapes. Plants commonly used in hedgerows and windbreaks — such as *Picea, Rubus, Taxus* and *Thuja* — are prone to weevil infestation. Mature plantings in nearby habitats can support very large weevil populations without noticeable injury and should be monitored closely and removed if necessary.

If infested plant material is discovered and damage is too severe or treatment options are not economical, these specimens should be immediately destroyed. Do not discard material near existing nursery stock — weevil larvae can complete their development in the root ball and migrate back into the nursery.

**Biological Control.** Biological control can be broadly defined as the use of natural enemies (predators, parasitoids and pathogens) to control pest populations. There are benefits — as well as limitations — to implementing a biological control program. As long as the user is aware of the issues surrounding biologicals, this method, when combined with effective cultural practices and pest monitoring, can be effective in the fight against black vine weevil.

The benefits of using biologicals include generally reducing re-entry intervals, decreasing the risk of secondary pest outbreaks and increasing specificity to the target pest. Biologicals are also more environmentally friendly than insecticides, and some of these agents are compatible with some chemicals. (Compatibility guidelines are noted on the label and should be followed carefully.) Furthermore, most biologicals can be applied with existing equipment.

Still, there are a number of limitations to these control agents. For example, although some can be used alongside chemicals, others cannot. Also, biologicals have a narrow host range, making targeting more than a single pest per application difficult, if not impossible. The efficacy of biological controls is also limited by the fact that some are more expensive than conventional insecticides, and all are subject to environmental conditions.

Historically, biologicals perform inconsistently, mainly due to poor product quality or user error. Nursery professionals who use biological control agents need to pay careful attention to how they store, handle and apply these organisms. The most important thing to remember when implementing a biological control program is living organisms — not chemical compounds — are being used and require the same care and consideration that any plant at the nursery receives.

**Attack of the Nematode.** The use of entomopathogenic (insect-killing) nematodes as a curative treatment for black vine weevil larval infestations has been commercially available for several years. Two genera of such nematodes, *Heterorhabditis* and *Steinernema*, are particularly effective against black vine weevil. Multiple species of each genus are commercially available for black vine weevil control, namely *H. bacteriophora, H. marelatus, H. megidis, S. carpocapsae* and *S. feltiae.* (A list of suppliers, as well as general information on the use of entomopathogenic nematodes, is available at www2.oardc.ohio-state.edu/nematodes/default.htm.)

During the infective juvenile stage, these nematodes locate weevil larvae by detecting signals emitted by damaged roots, as well as carbon dioxide and other host-associated cues. The host is then infected by nematodes entering through a natural opening (mouth, anus or spiracles — outside openings for the insect respiratory system) or by penetrating the insect directly. Once inside the host, nematodes release bacteria that multiply in the weevil larva, eventually killing it. The nematodes feed on the bacteria, reproduce, and, when the entire contents of the larva have been used, exit the larva cadaver and move through the soil in search of new weevil larvae.

Black vine weevil pupate in the top few inches of soil.

The life cycle of *Steinernema* and *Heterorhabditis* nematodes are similar; however, they locate weevil larvae differently. *Steinernema* spp. display an "ambush" behavior, waiting for a larva to move by and then attaching itself to it. *Heterorhabditis* spp. actively move through the soil profile in search of larvae. Due to their more aggressive searching behavior, *Heterorhabditis* spp. are generally more effective at controlling black vine weevil.

The infective juvenile stage of entomopathogenic nematodes is applied as a soil drench. Applications can be performed in various ways, depending on your nursery's production system and equipment availability. For instance, nematodes can be applied with standard spray equipment (remove any sprayer filters or they will become clogged), backpack sprayers or by injecting them into drip-irrigation systems.

When applying nematodes with sprayers, it is important to keep the agitator running to prevent settling. Dosage rates vary depending on the particular nematode being used, but are generally 35,000 to 45,000 infective juveniles per square foot. For optimum results, nematodes should be applied in spring or fall when late instars are present. The potting medium should be moist when the nematodes are applied, and medium temperatures should remain between 60° and 80° for two weeks after application.

Storage and handling is critical to ensure nematodes are alive, active and able to locate weevil larvae. Storage rec-

Once eggs hatch, black vine weevil larvae burrow into the soil, first feeding on small roots then moving to larger roots as the pests mature.

Although leaf notching can also signify mechanical damage, it is a good indication of adult black vine weevil activity.

ommendations vary between products and should be followed carefully — always check the label. Nematodes must be stored in a cool, dry place out of direct sunlight, and some may require refrigerated storage. Do not expose them to extreme temperatures, and do not allow them to freeze. Containers should not be opened until you are ready to use them; once the container has been opened, nematode suspensions should not be stored and reused.

Nematode viability can be easily assessed by placing a few drops of the suspensions you are going to apply onto a transparent material (glass or Plexiglas, for example) and observing them with a 10x hand lens. Live nematodes are various shapes (circular, J-shaped, S-shaped or actively moving), while those that are dead are straight and motionless. Suspensions with less than 90 percent nematode viability should not be used.

When a high-quality entomopathogenic nematode is applied properly under favorable environmental conditions, it can provide black vine weevil larval control comparable with most chemical insecticides. Nematodes require two to five days to kill their host, and speed of kill varies with soil temperature (slower kill when cool), so evaluations to determine the efficacy of nematode applications should be adjusted accordingly.

**Fear the Fungus.** Another biological that recently has been registered for use against black vine weevil larva is the fungus *Metarhizium anisopliae* (strain F52). The fungal product is being marketed by Earth BioSciences Inc., New Haven, CT, and will reportedly be available for commercial sale in spring 2005. In order to be infected with *M. anisopliae*, weevil larvae have to come into contact with the fungal spores. Fungal spores cannot move and, therefore, have to either be incorporated into the medium or possibly applied as a drench.

In my preliminary studies, the company's product (incorporated into peat and bark-based potting medium at a rate of $10^6$ spores per gram of potting medium) killed 96 percent to 100 percent of last instar black vine weevil larvae. Preliminary data also indicate *M. anisopliae*, when incorporated into the medium at potting, persists for up to one year at sufficient concentrations to provide high levels of weevil control. These results are from laboratory and screenhouse experiments and have not been verified in the field. Field experiments are planned for this growing season.

The effectiveness of a drench application of *M. anisopliae* as a curative treatment for infested nursery stock is currently underway. Further studies are being performed to determine how persistent *M. anisopliae* is in various types of potting media, as well as its compatibility with the various chemical and biological system inputs used in nursery production. Research is also being conducted on the optimal temperature range at which it is effective.

When used as a biological control agent, fungal spores attach themselves to larvae, killing the pests.

Regardless of the management strategy implemented, black vine weevil is a pest with which nursery growers will have to continually contend. However, with proper nursery management, the use of cultural control strategies, scouting, and the appropriate use of chemical or biological control tactics, this insect can be less of a burden on the nursery industry.

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