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Practical Black Vine Weevil Management

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Black vine weevil, *Otiorhynchus sulcatus* F, is the most obviously injurious insect pest of rhododendrons. Rhododendron enthusiasts are disheartened when purchasing precious species or hybrid plants, if they then find that the plant came with unwanted weevils "hitchhiking" in the roots. If the plant is small, feeding by black vine weevil larvae may cause sufficient root loss to kill the plant, or the larvae may girdle the main stem, with the same result. Larger plants can be affected in other ways. Root feeding can lead to nutrient deficiencies, because poorly functioning roots cannot translocate minerals available in the soil to the foliage. Finally, adult black weevils give plants a ragged appearance by notching the edges of leaves while feeding. This article is an update to my earlier review of black vine weevil biology (Cowles, 1995), and suggests practical approaches for managing this pest in nursery and landscape settings.

Management in Container-grown Nurseries

Control of black vine weevils in nurseries is especially important, both for protecting plants and to prevent transport of this pest. During the early development of rhododendron plants, there is insufficient root tissue on an individual plant to support the development of black vine weevil larvae, leading to plant girdling (Cowles, 1995). I have observed long-term effects of partial girdling and root loss on the growth performance of nursery plants, so any early effort to prevent this feeding can be expected to yield large benefits in terms of improved plant growth.

During the last five years, dramatic advances have been made to control black vine weevil populations in container-grown nursery crops. Five years ago, the standard for disinfesting, or ridding, container-grown nursery plants of soil-dwelling insect larvae was a drench or dip with chlorpyrifos (Dursban), an organophosphate insecticide. Besides being relatively hazardous to humans and wildlife, chlorpyrifos was also quite toxic to the roots of the treated plants (Mannion et al. 2000). Because of these problems, several researchers, myself included, conducted screening trials to determine if other insecticides could replace chlorpyrifos to prevent or eliminate existing soil insect problems, including both white grubs (Japanese and oriental beetles) and black vine weevil larvae. The winner in these trials was bifenthrin (Talstar), a pyrethroid - the only insecticide providing complete control of both scarabs and root weevils (Cowles et al. 1997; Nielsen and Cowles 1998). Pyrethroid insecticides, which are used extensively in agriculture and the home, break down quickly when exposed to sunlight. However, my studies showed that when bifenthrin is incorporated into potting media, it is protected from sunlight and its half-life (the time for half of the chemical to disappear) appears to be between three and four years!

Further investigations on black vine weevil larvae demonstrated that low concentrations of bifenthrin permitted some larval survival among certain plants (e.g., *Sedum* and *Astilbe*). This incomplete control probably resulted from internal feeding of black vine weevils in roots, and an interaction between the nutritional quality of the roots, root weevil larval behavior, and the distribution and concentration of bifenthrin in the medium. If larvae find a dense growth of highly nutritious roots upon which to feed, they may become sedentary, thus limiting the likelihood that, through their movement, they would encounter lethal quantities of the insecticide (Cowles, 2001). Since rhododendron roots are of relatively low nutritional value for black vine weevils, and internal feeding is not possible for the larvae, either incorporation of bifenthrin granules or drenches of a flowable formulation through the potting medium can be expected to give near-quarantine level control of black vine weevil larvae in rhododendrons.

Another effective method for controlling black vine weevils in container-grown nursery stock includes the use of entomopathogenic nematodes (Cowles et al. 1997, Gill et al. 2001). These nematodes, or roundworms, are almost microscopic pathogens of insects. They search through moist soil for susceptible insects, enter into their body cavity, and release symbiotic bacteria, which quickly multiply and kill the host. Two or three generations later, the infective juvenile stage of nematodes emerges from the bacterial-soup remnants of the dead insect, to seek out new hosts (www.oardc.ohio-state.edu/nematodes/). Therefore, because they propagate in hosts, application of nematodes may lead to improved control of root weevil larvae over time. My studies indicate that black vine weevil larvae are susceptible to virtually any commercially available species, including *Steinernema carpocapsae*, *S. feltiae*, and *Heterorhabditis bacterio-phora* (Cowles 1997).

The challenges for using entomopathogenic nematodes in the nursery setting are mostly due to their cost, and the fact that, since they are living organisms, they must not be subjected to extreme temperature conditions or stored for too long. Furthermore, they do not work well in preventive applications, because they need insect hosts in order to reproduce. Consequently, some degree of root injury would have to be tolerated if entomopathogenic nematodes are to be used as the principal management tool for root weevil larvae. However, if black vine weevil larvae ever develop resistance to bifenthrin, nematodes will become especially important in nurseries.

There is no excuse for nurseries to be shipping container-grown plants infested with black vine weevils, because very effective treatment options are now available. I suggest to retail nurseries receiving truckloads of plants that they inspect the insides of the shipping truck immediately after it is opened, so that the presence of adult weevils can be quickly detected. Since the inside of the unopened truck is dark, adult weevils wander out of their hiding places into the artificial "nocturnal" environment, and may be visible on the inside of the truck. If adults are present, then the recipient should inform the source nursery of the infestation. This can allow the source nursery to take corrective action in their plantings. Furthermore, the receiver needs to explore options and negotiate with the source nursery for determining who should pay for treatment costs when disinfesting the shipment.

The good news to rhododendron lovers is that methods available in nurseries for control of black vine weevils are environmentally superior, less toxic to humans, longer lasting and more effective than earlier organophosphate-based chemical control. In fact, it is plausible that control of root weevils in the nursery with either bifenthrin or nematodes may provide continued benefit in protecting these plants after their installation in the landscape. With a long half-life, bifenthrin can be predicted to be present in the potting mix at insecticidal concentrations long after the initial application, and would be present around the crown of the plant where protection from larval feeding is most important. Insect pathogenic nematodes are quite hardy, and as long as some susceptible insects are present, these roundworms could become permanently established in the landscape along with the nursery plants.

Management in the Landscape

Black vine weevils, and in some parts of the country, other species of root weevils, are very common denizens of the woods and urban landscapes (Maier 1986, Helm, 2001). Because they are common in surrounding vegetation, and the adults are peripatetic (Maier 1978; 1986), even when uninfested rhododendrons are planted, it is not likely that they will remain weevil-free. One approach to keep plants free of weevils, or alternatively, to prevent feeding on foliage, is to exclude adults from the plants with barriers (Cowles 1995, Helm 2001). Pruning foliage so that it does not touch the ground or bridge to other surfaces, and placing an unclimbable barrier (plastic coated with Tanglefoot, grease, or Teflon) on the main stem can prevent adult feeding on foliage (Helm 2001). This method should be especially useful for obtaining show-quality trusses free of weevil feeding notches on leaves. However, this approach may not protect the root system, because weevils could still lay their eggs in the soil surrounding the stem. Another type of barrier can prevent weevils from gaining access to the foliage or the root system, by excluding adults further away from the plant. Bury aluminum flashing so that the edge projects about 5 cm or more above the surface of the soil and mulch, and then coat the top few cm of this aluminum barrier with lithium grease (the sort of grease used by auto mechanics). A grease band provides many weeks of protection, even under extreme rainfall conditions (Cowles 1997). A disadvantage of this approach is its ineffectiveness if weevils are already present on the plant or find some way of getting into the enclosure. At that point, the barrier would no longer provide much benefit.

For many years, one objective in landscape pest control has been to prevent adult feeding injury to foliage, usually by applying broad-spectrum insecticides to the leaves to kill the feeding adults. The strategy makes sense in several ways: adult weevils are the only stage that is exposed above ground, and the adult weevil requires about a month of intensive feeding before she is able to lay eggs. Therefore, spraying at monthly intervals should break the black vine weevil life cycle.

This adulticide (adult-killing) strategy is unfortunately flawed in two important ways. First, black vine weevil populations appear to be surprisingly adaptable, considering that they reproduce asexually. Various populations of black vine weevil adults that I've tested in my laboratory survived applications of acephate (Orthene), chlorpyrifos (Dursban), endosulfan (Thiodan) and carbaryl (Sevin). More importantly, I have observed populations of adult weevils in nursery and strawberry fields that survived any of the insecticides already mentioned, along with azinphos-methyl (Guthion), bendiocarb (Turcam), fenpropathrin (Tame), and bifenthrin (Talstar). Putting it simply, some black vine weevils have apparently become resistant to any of the organophosphate, carbamate, or pyrethroid insecticides used for their control. Therefore, it is possible that the insecticides sprayed to kill the adult weevils in the landscape won't work.

A second reason that the adulticide strategy can be counterproductive is as follows: a wide variety of predatory ground beetles (carabids), both the adults and larvae, continuously cruise through leaf litter, the soil surface, and the soil in search of various insects to eat. These beneficial insects are probably more susceptible to the insecticides than are the weevils. Thus, if an insecticide-resistant weevil population is sprayed, the only result may be to chemically protect the weevils from their predators! The consequences of these dynamics can be extraordinary. In one field-grown yew nursery, where insecticides had been intensively used, I found (in a pitfall trap survey), approximately 1,500 black vine weevils and 200 predatory ground beetles. At the same time, in an unsprayed nursery, and with the same trapping effort, I recovered three black vine weevil adults and 950 predators. There were so few black vine weevils at this second site that the grower didn't even know that the pest was present. I have trapped about fifty-five species of these predators in commercial yew nurseries, ranging in size from 3 to 24 mm long. Depending on their size, carabids may be capable of eating weevil eggs and young larvae, or with the largest species, even be capable of eating several weevil adults.

To check on the relative abundance of carabids and black vine weevils, bury a 16 fluid ounce plastic cup up to the rim into the soil under or next to your rhododendron shrub. Coat the inside top inch of the cup with motor oil to make an unclimbable surface, and check the contents of this pitfall trap every few days. Neither carabids nor black vine weevil adults fly as adults, so any beetles that stumble in will be unable to climb back out.

Based on field observations, I can suggest that management of black vine weevils in the landscape should principally be based on biological control. If there is much weevil feeding on foliage, then efforts to establish insect pathogenic nematodes in the soil are probably warranted. If you do apply nematodes, irrigate the soil beforehand, check with a hand lens to make sure that the commercially-grown nematodes are alive and wiggling, and keep the soil moist with intermittent watering for a few weeks following application. May or late-August application timing appears to be appropriate for targeting weevil larvae (Cowles 1997). Since root weevils develop very well on many other kinds of plant materials (such as arborvitae, spruce, hydrangeas, ferns, and many broad-leaved perennials), take care to apply nematodes to reduce the numbers of larvae feeding on these plants, too. Nematodes reproduce best in an environment with a high population of hosts, so expect the best results where there is the greatest concentration of root weevil larvae.

While some researchers have thought northern soils are too cold for entomopathogenic nematodes to succeed, or even survive (Rutherford et al. 1987, Helm 2001), my field surveys in Connecticut, and additional surveys in New York, Oregon, and the Canadian Rockies have demonstrated the natural occurrence of these nematodes (Fergusen et al. 1995, Liu and Berry 1995, Mracek and Webster 1993). The only way that these nematodes could be present at these sites would have been for them to successfully infect and reproduce in hosts, and to survive from one year to the next. Finding native populations of nematodes at these sites proves that insect pathogenic nematodes can survive in northern and cold climates, but does not guarantee that these natural populations will be effective in suppressing root weevil populations. One interpretation of black vine weevil's life cycle is that egg-laying as late as September (my observations), and the ability of larvae to develop at temperatures below 11°C (Stenseth 1978), may be adaptations that permit larvae to develop at times of the year when soil temperatures are too cold for insect pathogenic nematodes to reproduce. Therefore, applying nematodes may still be necessary to provide sufficient numbers of nematodes in the brief periods of time when larvae or pupae are present and soil temperatures are warm enough for an infection cycle to take place. Based on field survey data, if susceptible hosts are present, these nematodes can become permanently established following their application.

Because many predatory ground beetles are generalists, eating virtually anything that moves and is small enough for them to consume, their continued existence in a landscape is independent of the presence of root weevils. When they don't have weevils to eat, they can sustain themselves by feeding on various other insects that live in the soil, mulch, and leaf litter. Therefore, they can outnumber root weevils and keep them at low populations. It is known that cultivation, insecticides, and some slug and snail baits adversely affect carabids (Cilgi et al. 1996), so avoiding excessive hoeing and these products may help to conserve the predators. Manipulating the habitat to encourage these predators could also be beneficial. They do well in environments protected from the sun, so coarse mulch should increase their activity (Wilson et al. 1999). The gradual decomposition of mulch should provide many additional benefits to rhododendrons (weed control, conservation of water, and additional organic matter), and can serve as the food for detritivores (small insects and earthworms) essential, in turn, for feeding carabids.

Conclusion

My past twelve years of work on black vine weevils, generously supported by the American Rhododendron Society, have caused me to have a tremendous respect for this insect. While the adulticide approach theoretically should give good control of this pest, insecticides have not yet been found that can selectively kill weevil adults rather than beneficial predators. Part of this challenge is the superior ability that weevils have for coping with poisons, which is probably a preadaptation evolved from feeding on the foliage of what, to us, are highly toxic plants (e.g., rhododendrons and yews). To be appropriate for use in the landscape, an insecticide useful for killing black vine weevil adults must either take advantage of internal physiological differences between black vine weevils and predatory ground beetles, or would have to specifically be toxic to weevils only through ingestion. Although carabids won't eat rhododendron leaves, they are sufficiently omnivorous to be poisoned by apple fiber-based insecticidal weevil baits (Cowles 1996).

Overall, taking advantage of the black vine weevil's natural enemies entomopathogenic nematodes and predatory ground beetles, probably has the best chance for protecting rhododendrons from serious root injury. To accept this strategy, rhododendron fanciers will have to accept a certain amount of leaf notching. Permitting a few weevils to feed on the foliage should not jeopardize the health of established plants, and a small amount of weevil feeding is a sign that the landscape has a healthy, multi-layered ecosystem, complete with prey and predators.

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