Biological Control of Black Vine Weevil Larvae in Cranberry

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Black vine weevil in cranberry production

Black vine weevil (*Otiorhynchus sulcatus*) is an important insect pest of cranberry (*Vaccinium macrocarpon*) and other small fruit crops in the Pacific Northwest (Figure 1). Adult feeding on foliage is of little economic importance, but it is the most obvious sign of black vine weevil (BVW) activity, appearing as notching along the leaf margin. Larval damage to roots is a greater economic concern. Developing larvae feed on fine roots and can girdle larger roots, reducing the root system's ability to move water from the soil to the foliage (Figure 2). In midsummer, rising temperature and water demands coincide with increased feeding as the larvae mature. During this hot, dry period, heavily damaged vines wilt, turn brown, and may die. The leaves of moderately damaged vines will redden earlier in the season than those of uninfested vines (Figure 3, page 2). Damaged vines do not recover when cooler, wetter weather returns.

Female BVW adults are capable of laying eggs without mating. Researchers in British Columbia reported that adult female BVW that fed on cranberry foliage laid an average of 163 eggs per female per season. Seventy-four percent of these eggs developed to adulthood (see Cram and Pearson in "Resources," page 5). More than 12 BVW larvae per square meter (about 1 larva per square foot)

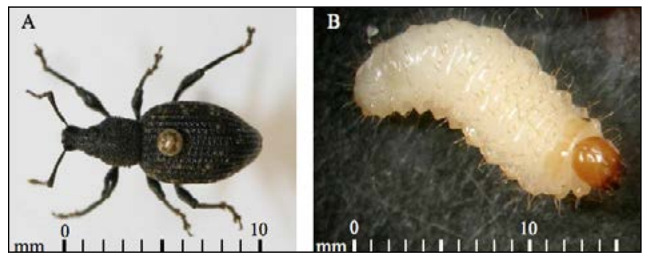

Figure 1. Adult black vine weevil (A) feeds on foliage, but it is the larva (B) that causes damage of economic concern to cranberry by feeding on roots.

Figure 2. 10× magnification of BVW-damaged cranberry shows extensive girdling (bottom) in comparison with the healthy vine (top).

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create patches of dead or dying vines within two years. Damaged areas left untreated may quadruple in size within one year.

In our study of container-grown cranberry that were intentionally infested with BVW eggs, the highest infestation rates corresponded to the greatest reduction in shoot weight and length. In addition, vines with greater rates of infestation had significantly less green leaf area than vines with lower rates of infestation. Thus, BVW damage appears to have a negative impact on the plant's capacity to synthesize sugars that will be stored in developing berries and other vine tissues (Figure 4).

Figure 3. Left, a BVW-damaged cranberry vine exhibits girdling, few fine roots, and reddened foliage. For comparison, a healthy vine is shown on the right.

Figure 4. Container grown cranberry plants showed a decrease in vigor and green leaf area as they were inoculated with increasing numbers of BVW eggs. The number of eggs increases incrementally from container A (no eggs) to container F (80 eggs).

Management of black vine weevil

Managing BVW in cranberry is difficult because larvae dwell exclusively in the soil, and adults are active only at night. Monitoring for adults is done with a sweep net after dark in late May and June. Economic thresholds for BVW in cranberry are not well defined, and treatment is recommended if any BVW are found.

There are few effective ways to control BVW in cranberry. One method of cultural control is to leave harvest floodwaters in place for 2 to 3 weeks, while temperatures are warm. This may drown large numbers of young larvae, but the technique is not 100 percent effective, nor is it possible on all sites.

Organophosphates, such as acephate, and systemic neonicotinoids, such as imidacloprid and clothianidin, are two major groups of chemical insecticides labeled for use against BVW in cranberry. There are a number of concerns about these products:

- Adult BVW appear to have a tolerance for many organophosphates.
- The below-ground damage caused by larvae goes unseen, making treatment difficult to time.
- The soil-dwelling habit of larvae protects them from contact with imidacloprid.
- Soil organic matter ties up imidacloprid and reduces its effective concentration. Production trials in Washington state have shown 90 percent BVW control with imidacloprid in sandy soils but only 50 percent control in peaty soils.
- Pollination by wild bees and honeybees is essential for crop set. Imidacloprid is highly toxic to bees. It is important to follow all label instructions carefully to minimize risk to pollinators.
- Application timings can be restricted by long pre-harvest intervals as indicated by the pesticide label.
- At times during the cranberry production cycle, surface water flows through the beds, creating the potential for water contamination if conventional pesticides have been applied.

Figure 5. *M. anisopliae* is sold as an emulsifiable concentrate (EC) or granular formulation. Only the EC is labeled for drench application.

Figure 6. Fungus-infected BVW larvae among cranberry roots (bottom). Healthy BVW larvae were placed in the cup for comparison (top).

Our research indicates that chemical insecticides are inconsistent management tools for BVW in soils with high organic matter content. However, effective biocontrol agents have real potential as alternatives.

Biological control agents of BVW

Field-based research with the fungus *Metarhizium anisopliae* and the nematode *Steinernema kraussei* (both of which infect and kill BVW larvae) have shown that these biocontrol agents are at least as effective as imidacloprid in controlling BVW.

Insect-killing fungi: *Metarhizium anisopliae*

We tested *M. anisopliae* (strain Met52, distributed by Novozymes Biologicals, Inc.) applied as a soil drench at label rates (Figure 5). *M. anisopliae* is labeled for use in cranberry and other fruit crops in the United States. *Beauveria bassiana* is another commercially available fungus that is approved for control of BVW.

Insect-killing fungi like *M. anisopliae* infect the insect host by growing through the exoskeleton and into the insect body (Figure 6). *M. anisopliae* can also thrive on root exudates in the narrow zone of soil surrounding developing roots. This allows *M. anisopliae* to persist in the soil when no insect host is available, an advantage for long-term biological control.

M. anisopliae is best applied at air temperatures of 12 to 25°C (54 to 77°F), relative humidity greater than 96 percent, and soil moisture levels between 6 and 18 percent. Timing of application must also take into consideration any fungicide residues because fungicides applied to the crop can negatively affect *M. anisopliae*. Increasing levels of zinc, copper, and sulfur in soils inhibit growth and virulence of the fungus. Temperature and moisture extremes also appear to reduce its action. In locations with naturally occurring populations of *M. anisopliae*, its virulence decreases as soil water content increases. Saturated beds may reduce persistence of *M. anisopliae* in the soil.

M. anisopliae is well suited for the pH range favoring cranberry production. It is more active in undisturbed soils with extensive root networks, such as those found in cranberry beds. In our study, it remained active in soils for up to two growing seasons in Oregon and Washington. Where no fungicides were applied, its activity was as high in September of the second year as in September of the first growing season, when it was applied. The activity of any soil fungus should be expected to vary over the course of the year.

Insect-killing nematodes: *Steinernema kraussei*

We tested *S. kraussei* (distributed by Becker Underwood, which is currently part of BASF) applied as a soil drench at label rates (Figure 7). Nematodes can be applied much like chemical insecticides, although greater attention must be paid to the conditions under which they are stored and applied. *Steinernema carpocapsae* is another species of predatory nematode commercially available for control of BVW.

S. kraussei, like most nematodes, is temperature, moisture, and UV-light sensitive (Figure 8). Optimum application conditions are low or filtered sunlight and high humidity. *S. kraussei* is most active against BVW larvae at temperatures of 5 to 20°C (40 to 68°F). *S. kraussei* is active at lower temperatures than other commercially available nematodes recommended for BVW.

S. kraussei requires an insect host to complete its life cycle. As BVW populations come under control and fewer larvae are available, *S. kraussei* populations decline as well. In our study, *S. kraussei* provided a shorter window of control than *M. anisopliae*, and when used alone did not result in significant BVW mortality.

Incorporating biocontrol into your BVW management program

In our study, *M. anisopliae* killed more BVW larvae overall than either *S. kraussei* or imidacloprid. The insect-killing fungus

Fungicide applications must always be considered carefully in any production system in which beneficial fungi are used. Common fungicides used in cranberry production have been tested for compatibility with *M. anisopliae*. Products are listed here in order of *M. anisopliae's* increasing sensitivity to them:

- Copper sulfate – minimally toxic to *M. anisopliae.*
- Chlorothalonil – moderately toxic. Common label names include Echo and Bravo.
- Mancozeb – potential for severe toxicity. Common label names include Dithane, Penncozeb, and Manzate.
- Azoxystrobin – potential for severe toxicity. Common label name is Abound.

Copper hydroxide, widely recommended for use in cranberry production, has not been evaluated for compatibility with *M. anisopliae.*

We have seen persistent reduction of BVW larvae when using both *M. anisopliae* and *S. kraussei*, compared to standard chemical controls. In addition, these two organisms are nontoxic to the environment and more pest-specific than broad-spectrum insecticides. However, it must be noted that their efficacy and persistence are highly dependent on environmental conditions.

Figure 7. *S. kraussei* (shown in a tray) must be mixed with water before application as a soil drench.

Figure 8. *S. kraussei* is a soil-dwelling, microscopic, predatory nematode that infects BVW larvae.

appears to be at least as effective as imidacloprid, although control was inconsistent across the growing season. *M. anisopliae* reduced BVW larvae in Pacific Northwest cranberries for at least two growing seasons. Used alone, it resulted in higher overall mortality than *S. kraussei* alone and has potential for economic control of BVW in cranberries.

We recommend routine maintenance of resident populations of *M. anisopliae* in the soil to provide a sustained control of BVW, with supplemental applications of *S. kraussei* according to label recommendations during BVW outbreaks (Figure 9 A–D).

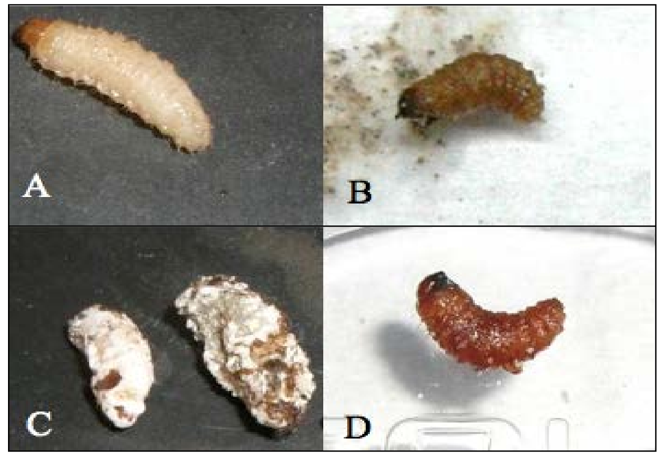

Figure 9. Black vine weevil larvae shown as (A) healthy, (B) infected by the nematode *S. kraussei*, (C) infected by the fungus *M. anisopliae,* and (D) poisoned by imidacloprid.

OSU Extension Service publications

Available online at https://catalog.extension.oregonstate.edu/

PNW Insect Management Handbook (Cranberry-Root weevil: http://insect.pnwhandbooks.org/small-fruit/cranberry/cranberry-root-weevil)

Other resources

Cram, W.T. and W.D. Pearson. 1965. "Fecundity of the black vine weevil, *Brachyrhinus sulcatus (F.)*, fed on foliage of blueberry, cranberry, and weeds from peat bogs." *Proceedings of Entomological Society of British Columbia*. 62: 25–27.

Miller, E.A. 2011. "Assessment of black vine weevil larval damage to cranberries and development of alternative control strategies." OSU MS thesis (http://ir.library.oregonstate.edu/xmlui/handle/1957/20929)

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