



BUL 942

# Sugar Beet Root Maggot:

## *Identification, Biology, and Management\**

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### Introduction

THE SUGAR BEET ROOT MAGGOT, *Tetanops myopaeformis* (von Röder), occurs wherever sugar beet is grown in Idaho. It is native to North America but did not become a serious pest in Idaho until the 1960s. Infestations historically have been the most damaging in Minidoka and Cassia Counties. However, localized infestations also may occur around Filer in Twin Falls County, near Notus and the Dry Lake area of Canyon County, and near American Falls in Power County. Infestations seldom reach damaging levels in other areas.

This publication will help you to design an integrated pest management (IPM) program for the sugar beet root maggot. The IPM approach combines cultural controls with field scouting and thresholds to ensure that insecticide controls are used only when needed. Beet growers who use IPM can increase profits while reducing potential harmful effects associated with pesticides.

*\*Modified from a previous publication written by Bechinski et al. (1994).*



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## Pest Description

Sugar beet root maggots develop through four life stages: egg, larva, pupa, and adult.

- Eggs are white, slightly curved, and about  $\frac{1}{5}$ -in (1-mm) long (Figure 1).
- Larvae are whitish legless maggots without distinct heads. The body grows to  $\frac{1}{3}$ -in (8-mm) long, tapering to a cone at the head (Figure 2).
- Pupae are brown with a hard-shelled capsule and are slightly smaller than full-grown larvae (Figure 3).
- Adults are medium-sized flies with two wings and a shiny, black body (Figures 4A and 4B). (Refer to the *Scouting, thresholds, and insecticides* section for a more detailed description of adult flies.)



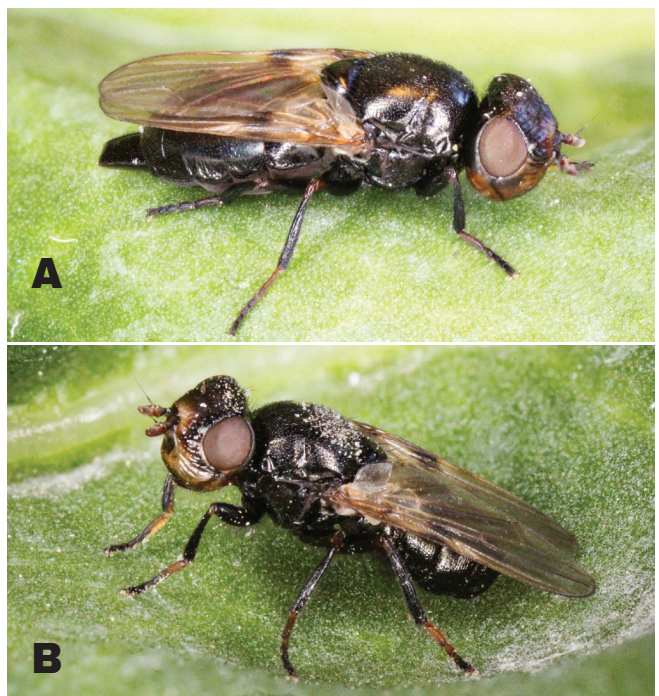
**Figure 1.** Eggs of sugar beet root maggot. Female flies lay their eggs on or near sugar beet plants, within the soil. Photo by Erik J. Wenninger, University of Idaho.



**Figure 2.** Third instar larva of sugar beet root maggot. Photo by Erik J. Wenninger, University of Idaho.



**Figure 3.** Pupa of sugar beet root maggot. This is a mature pupa; its body is receding from its pupal case and it is nearly ready to emerge as an adult. Photo by Erik J. Wenninger, University of Idaho.



**Figure 4.** Adult female (A) and male (B). Note the ovipositor on the female as well as—on both sexes—the brown patch on each wing and yellowish “knees” on each leg. Photos by Erik J. Wenninger, University of Idaho.



## Life Cycle

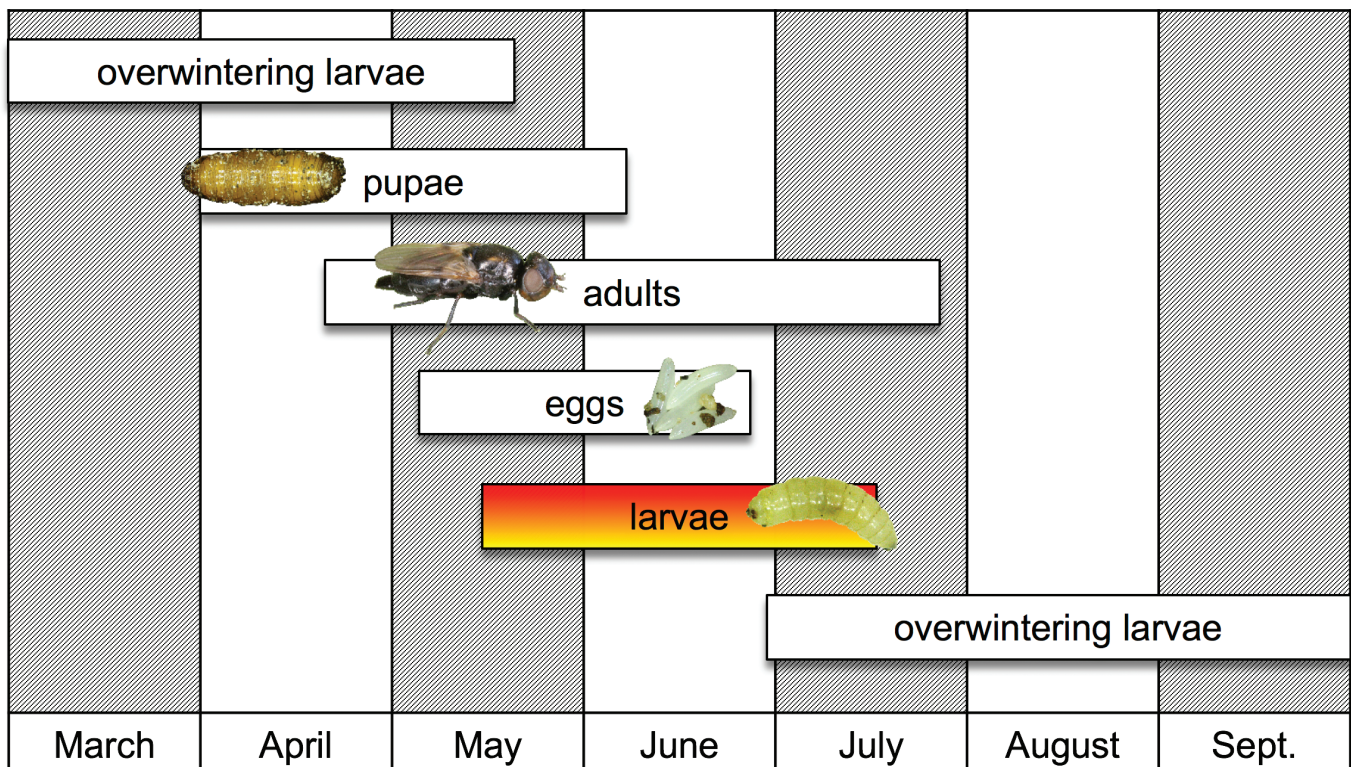
(Figure 5) Sugar beet root maggots overwinter as full-grown larvae 1 or more ft deep in the soil of the previous year's beet fields. As soil temperatures warm to the mid-40s (°F) during the spring, maggots move upwards and pupate within a few inches of the surface. Fly emergence typically begins during mid-April in western Idaho and mid-May in eastern Idaho but can occur sooner or later depending on spring temperatures.

Fly numbers in most areas are usually low until late May. Populations then increase rapidly and reach seasonal peaks during late May to early June. Fly numbers may decline to undetectable levels within a week or so after they peak. One exception to this general pattern occurs in the Mini-Cassia area (Minidoka and Cassia Counties), where fly populations often begin to build by mid-May and remain at high levels for several weeks. In all areas, cool, wet, and windy weather slows adult emergence and limits adult flying behavior whereas unseasonably warm spring temperatures advance

fly emergence. During periods of cool temperatures, adults remain still on the soil surface and do not fly even when prodded. They have nutritional reserves to live without feeding for two or more weeks. Nectar feeding on flowering plants, including weeds, prolongs their lifespan.

Adult flies begin to lay eggs 3–10 days after emergence. Females have an *extendible ovipositor* (egg-laying tube) that they use to deposit batches of 8–15 eggs in the soil next to sugar beet plants. Over her life, each female can lay about 120 eggs. Eggs hatch in 1–3 days. Soil moisture is critical for egg survival; eggs die without hatching if the soil is hot and dry.

Maggots feed on sugar beet roots and develop through three larval stages. They reach full size early to mid-July, after which they stop feeding and enter a state of diapause until the following spring. During diapause, larvae do not feed. Usually a single generation develops annually; however, there is some evidence that a small portion of the population pupates during July and emerges as flies during August.



**Figure 5.** Generalized life cycle of the sugar beet root maggot (March through September). Non-overwintering larvae represent the only stage that is damaging to sugar beet. Photos by Erik J. Wenninger, University of Idaho.

## Host Plants and Damage

Only larvae cause damage. They reduce tonnage and sucrose content by scraping the root surface with their rasping mouth hooks. They do not tunnel into the beet like wireworms nor do they feed aboveground like cutworms or crown borer larvae. Only maggots hatching from eggs laid during the current growing season cause injury. Overwintering larvae never feed on the crop during the spring.

### Damage to Seedlings

Crop losses depend on the number of maggots present and on the size of the sugar beet plant. Seedlings are the most susceptible to injury because maggot feeding can sever the taproot and kill the plant (Figure 6). Probability of stand loss is greatest for late-planted fields that are in the seedling stages when flies reach seasonal peaks.

### Damage to Older Plants

On older plants, maggot feeding damage appears as black, oozing lesions ranging from pinhead to dime size (Figure 7). When infestations are severe, lesions may cover the entire root surface. Feeding on the root tip of young plants can cause the taproot to fork and branch as it continues to grow (Figure 8). Above ground, damaged plants wilt during May and June, especially between irrigations (Figure 9). Direct losses are compounded when root-rot pathogens invade feeding wounds. In fields with histories of root rots, even minor root maggot infestations can combine with soil pathogens and eliminate the stand.

### Alternative Host Plants

Sugar beet, table beet, Swiss chard, and spinach are the only commercial host plants. Spinach is the preferred host for adult egg-laying as well as for larval development. The only known weedy host plants are spear saltbush (*Atriplex patula*) and garden orache (*Atriplex hortensis*), an herb that has escaped cultivation. Extensive testing with other weeds has shown that none of the following is a host: black nightshade, curly dock, prostrate pigweed, and Russian thistle. Flies will lay eggs on common lambsquarters and redroot pigweed when no sugar beet is present; however, survival rates of maggots on these plants are lower than on sugar beet.



**Figure 6.** Damage to sugar beet seedling. Severing of the tap root killed this seedling. Photo by Erik J. Wenninger, University of Idaho.



**Figure 7.** Damage to older sugar beet root. Black, oozing lesions are visible. Photo by Erik J. Wenninger, University of Idaho.



**Figure 8.** Forking of damaged sugar beet root. In addition to causing black lesions, feeding on the root tip of young plants can cause the taproot to fork and branch as it continues to grow. Photo by Erik J. Wenninger, University of Idaho.



**Figure 9.** Wilted sugar beet next to a healthy sugar beet. Wilted, dying plants may be the first observed symptom of root feeding. Photo by Erik J. Wenninger, University of Idaho.



Since larvae have a narrow host range and adults tend not to fly long distances when hosts are available, areas with extensive sugar beet acreage provide a better environment for this pest. This may explain why populations perennially reach damaging levels only in certain areas (i.e., areas with high densities of host plants).

## Designing an IPM Program

### Cultural control

**Early planting.** Root maggot management begins with cultural methods that reduce the numbers of flies colonizing fields and laying eggs. Crop rotation helps control this pest but is ineffective by itself because flies move among neighboring fields. Thus, early planting can give beets a head start on root maggots, allowing the crop to develop beyond the susceptible seedling stage when maggot feeding begins.

**Tillage.** Deep fall tillage after harvest exposes overwintering larvae to freezing temperatures and naturally occurring predators. In Idaho, conservation tillage approaches, including strip tillage, have been shown to be favorable to certain spiders, predatory ground beetles, and harvestmen (“daddy longlegs”), which should reduce root maggot densities.

**Irrigation scheduling.** This strategy also can decrease plant injury. Frequent irrigation forces larvae toward the soil surface where feeding causes less injury and where exposure to insecticides may be greater. However, overwatering encourages the development of soil-borne pathogens. When practical, also avoid planting sugar beet in fields with sandy-textured soils; damage is often greater in lighter soils, possibly because larvae are not driven toward the surface by high soil-moisture levels.

**Other approaches.** Other cultural practices are less useful. Weed control does not aid in root maggot management because none of the common sugar beet weeds are important host plants. In theory, planting a border of spinach as a trap crop around fields could attract egg-laying flies away from sugar beet, but this tactic has not proven effective in Idaho. The use of cover crops in sugar beet can be beneficial because it enhances soil moisture, thus encouraging larvae to move toward the soil surface where exposure to insecticides may be greater. Cover crops should be favorable to predatory arthropods as well, which would contribute to control.

### Host plant resistance

Researchers have been working on root maggot-resistant sugar beet lines for several years, but they have yet to release any commercial varieties with acceptable yield potential. Recent focus of research in this area may yet produce commercially acceptable varieties with resistance.

### Biological control

Naturally occurring predators of larvae and/or pupae include ground beetles, stiletto flies, and birds, as well as two soil fungi: *Metarhizium anisopliae* and *Fusarium solani*. Unfortunately, we do not know enough about our native beneficials to suggest practical ways of manipulating them to provide consistent and reliable control of root maggots.

Furthermore, no commercial biocontrols are available. The two fungi mentioned above as well as the bacterium *Bacillus thuringiensis* are promising pathogens that could be developed into biological insecticides, but chemical companies have yet to develop them specifically for managing sugar beet root maggot larvae. Other potential microscopic natural enemies include nematodes that seek out and kill larvae, but tests in Idaho have thus far shown them to be ineffective. Researchers are also investigating biopesticides that kill larvae by disrupting their digestive bacteria, but those applications are not yet available.

### Pheromone-mediated management

Researchers have developed an aggregation pheromone lure that is attractive to both female and male flies. This new tool will improve monitoring techniques and may lead to new management approaches, including mass trapping or attract-and-kill. However, this work remains in the preliminary stages as well.

### Scouting, Thresholds, and Insecticides

These three components comprise the most widely used management approach for root maggots. In most areas in Idaho, post-emergence applications are more cost-effective than at-plant applications. This especially is true in sprinkler-irrigated versus surface-irrigated fields. Post-emergence treatments are more effective in part because there is no way to know at planting time if insecticides are needed.

Root maggot flies do not begin to lay eggs until 4–6 wks after planting. Moreover, even if infestations do develop, at-plant applications occur too early to achieve maximum larval kill. Research has shown that maggot control is most effective when insecticides are applied within ten days of peak fly emergence, which more closely coincides with the period of peak larval hatching. Exceptions include the Mini-Cassia and American Falls areas; see the sidebar “Maggot scouting and thresholds in the Mini-Cassia and American Falls areas” for specific recommendations. The most effective insecticides for sugar beet root maggot are granular products applied to the soil that target the larvae.

**Sticky stake traps.** You can determine when adult flies are emerging by monitoring populations with Blickenstaff\* sticky stake traps. The traps consist of a 2 × 2-in (nominal size) white wooden post with an orange sticky strip or stake tacked or stapled to one side (Figure 10). Adult flies are attracted to the orange surface where they are captured in a film of insect-trapping adhesive. Orange garden stakes (about 1.125 × 12 in) can be purchased through various online garden and greenhouse supply companies and a film of insect-trapping adhesive applied over the strip. One commercial brand of trap adhesive is Tangle-Trap; it is available from various retailers that sell insect-monitoring tools. The aerosol spray formulation is easier to use than the brush-on types.



**Figure 10.** Orange sticky stake trap deployed adjacent to a sugar beet field. Inset: close-up of numerous adult sugar beet root maggot flies on a sticky trap. Photos by Erik J. Wenninger, University of Idaho.

Sticky stake traps capture many different types of insects. Use this combination of features to differentiate sugar beet root maggot flies (Figures 4A and 4B) from other common species:

- **Size:** ¼-in (6-mm) long, stocky, stout-bodied appearance superficially similar to houseflies; the tip of the male’s body is rounded and the female’s body comes to more of a point.
- **Color:** shiny, oily black body, without obvious stripes, bristles, or hairs.
- **Wings:** one transparent pair with a smoky brown patch located along the leading edge, about one-third of the distance from where the wing attaches to the body.
- **Legs:** entirely black except for yellowish-white “knees” and “ankles.”

Other flies that are commonly collected on sticky traps include flies in the family Anthomyiidae (beet leafminer, onion maggot, and seedcorn maggot flies; Figure 11). These anthomyiid flies are similar in size to root maggot flies but are dull grayish in color and have obvious bristles on their bodies. March flies also are commonly captured on sticky traps. They are about twice the size of sugar beet root maggot flies and have a long-legged appearance. Each wing is marked with a black, oval spot that is more distinct than the brownish smudgelike patch on the wing of the sugar beet root maggot fly. March flies are not harmful to plants.



**Figure 11.** An anthomyiid fly (lower left) can be distinguished from sugar beet root maggot flies (circled) by their grayish color and obvious bristles on the body. Photo by Erik J. Wenninger, University of Idaho.

\*Dr. Carl Blickenstaff, United States Department of Agriculture-Agriculture Research Service Research Entomologist, conducted the original research that resulted in this trap design.

**Using sticky stake traps. Although the procedure is simple, you must follow these instructions:**

1. Use three or more traps per field. Place traps along the fencerow or along the ditch bank next to the sugar beet field. Do not place traps within the field. Locate traps where you can easily check them; space them at intervals of several hundred yards. Point the orange face either north or east with the bottom of the orange strip 1 ft above ground level. Trim back any weeds that block or interfere with the trap.

## **Maggot Scouting and Thresholds in the Mini-Cassia and American Falls Areas**

Be advised that heavy, prolonged fly emergence often occurs in the area north of Rupert and Paul as well as the area south of Burley from Milner to Declo. Fly captures frequently exceed the threshold of 40–45 flies by mid-May and continue increasing for three or more weeks, eventually reaching peaks of several hundred flies. More recently, similarly high captures of flies have been observed in the area west of American Falls. Consequently, growers in these areas should not wait until peak capture before applying insecticides for maggot control. Instead, they should split the applications into at-plant and post-emergence treatments. This will extend the insecticide's effectiveness. Furthermore, they should not permit granules to touch the seed when applying the insecticide at planting time because this can result in plant injury (phytotoxicity). Growers in these areas should continue to use sticky stakes as an aid to time post-emergence treatments. Make applications as soon as fly numbers exceed economic thresholds. Do not delay.

2. You can save scouting time by monitoring one field, but more accurate information is obtained by monitoring every field. Patterns of fly activity can differ substantially even among adjacent fields.
3. Begin trapping by April 15 in the Treasure Valley of western Idaho and by May 1 elsewhere. Check traps at least twice weekly. The time of day you check traps does not matter. Frequent checking is best because dusty winds coat the trap with dirt and reduce capture efficiency. Additionally, traps sometimes capture so many other insects that they cover the entire orange surface and prevent further captures.
4. After checking each trap, replace the sticky strip (if using a commercial trap) or scrape the orange surface clean with a putty knife and reapply trap coating (if using a homemade trap).
5. Check traps until you see a definite peak in fly captures. Although captures can change erratically, seasonal peaks normally occur between May 23 and June 7. Warm weather advances these dates; cold, windy, and rainy weather delays them.
6. Keep records. Each time you check the traps, record the number of sugar beet root maggot flies each captured. Then calculate the *trap average* (the average number of flies per trap). Divide the trap average by the number of days since the last time you checked your traps. The resulting value is the *daily average* and is necessary to adjust for any differences in time intervals between checks. Without this correction, you might incorrectly identify the date of peak capture and make the wrong control decision. Finally, keep a running tally of your trap averages from the beginning of the season.

**How to make a control decision.** When the daily average column shows that captures of root maggots have peaked, you are ready to make a control decision. Compare the *running tally* on the day of peak with the thresholds in Table 1. If your running tally is greater than the thresholds, apply an insecticide. But if your tally is less than the thresholds, control is not needed because yield losses from maggot feeding will be less than the cost of purchasing and applying insecticides.



The running-tally example (Figure 12) indicates that the daily average reached a peak of 10 flies on May 25. The *running tally* for that day was 50 flies. In that case, you would next consult the thresholds in Table 1 to see if 50 flies justify using insecticides for larval control. For instance, assume that your contract price is \$40 per ton and that it costs \$20 per acre to purchase and apply a granular pesticide. Table 1 states that the threshold is 43 flies. In this example, the infestation is severe enough to require control. But if fewer than 43 flies had been captured, the action threshold calculations would indicate no insecticide is needed. As a rule of thumb, maggot control is justified if each trap captures an average of 40–45 flies from the beginning of the season until peak. Unless you capture an average of at least 34 flies per trap, yield losses will be too small to justify applying a granular insecticide.

When peak fly captures exceed thresholds, apply insecticides within ten days. The longer the delay between peak fly capture and insecticide application, the less effective larval control will be. Contact your University of Idaho County Extension Educator or crop consultant with The Amalgamated Sugar Company for information about currently labeled insecticides.

When using granular insecticides, know that they require moisture after application to move the active ingredient into the root zone. In sprinkler-irrigated fields, apply the insecticides over the top of the row, lightly incorporate them, and irrigate as soon after application as possible. Always read the insecticide label for specific recommendations regarding placement.

**Degree-day model.** A degree-day model is an approach to predict the timing of peak activity of a pest based on the accumulation of “degree days” over the calendar year. You can predict the date of peak seasonal flight by using the sugar beet root maggot degree-day calculator posted online at <http://uspest.org/wea/index.html>. Five years of research in eighty-three

commercial sugar beet fields across southern Idaho show that peak fly capture occurs on the first day the air temperature exceeds 80°F following 360 total degree-days above 47.5°F since March 1. Prediction accuracy averages +/- 5 days, meaning that the actual date of peak seasonal fly capture most likely will occur within the period from five days before to five days after the predicted date. The online calculator predicts the peak date by tracking air temperatures at a local weather station that you select as well as by using

**Table 1.** Action thresholds for sugar beet root maggot. Thresholds are the average number of flies trapped from the beginning of the season until peak capture. Control is not needed unless the average number of flies captured per trap from the beginning of the season until peak is greater than these thresholds. An interactive version of this table where you can easily compute precise thresholds can be found here: <http://www.srcoop.com/coopEconomicThresholdsCalculator.aspx>.

Contract price (\$/ton)	Cost of insecticide and application (\$/acre)			
	10	20	30	40
20	43	51	59	67
30	40	45	51	56
40	39	43	47	51
50	38	41	44	47

Date	No. flies captured			Total	Trap average (average no. flies per trap)	No. days since trap last checked	Daily average (average no. flies per day)	Running tally (total trap averages since beginning)
	trap 1	trap 2	trap 3					
May 1	put traps out							
May 4	0	0	0	0	÷ 3 = 0	÷ 3 =	0	0
May 7	0	1	2	3	÷ 3 = 1	÷ 3 =	0.3	1
May 12	3	0	0	3	÷ 3 = 1	÷ 5 =	0.2	2
May 18	3	1	2	6	÷ 3 = 2	÷ 6 =	0.3	4
May 22	14	11	23	48	÷ 3 = 16	÷ 4 =	4	20
May 25	34	25	31	90	÷ 3 = 30	÷ 3 =	10 Peak!	50 ✓✓
May 28	10	7	19	36	÷ 3 = 12	÷ 3 =	4	62
June 1	4	5	3	12	÷ 3 = 4	÷ 4 =	1	66
	+	+	=		÷ 3 =	÷ =		
	+	+	=		÷ 3 =	÷ =		
	+	+	=		÷ 3 =	÷ =		
	+	+	=		÷ 3 =	÷ =		

**Figure 12.** Keep written records of trap captures. Calculate the average number of flies per trap as well as the average per trap per day.



seven-day weather forecasts. However convenient, the degree-day model for sugar beet root maggots should only be used as an aid in predicting peak flight, not as a replacement for monitoring with sticky stake traps, which provide the most accurate information on fly populations at the field level.

**Seed and foliar insecticides.** Several insecticide seed treatments are available for control of the larval stage of sugar beet root maggots. In fields with low-to-moderate root maggot pressure, seed treatments may be effective; however, for heavy infestations additional control measures (including granular insecticides applied near peak flight) are needed. There appear to be no substantive differences in efficacy among seed treatment options.

Although foliar insecticide sprays may reduce adult numbers, repeated applications are needed to inhibit egg laying over an extended period. Frequent foliar spraying encourages the development of insecticide resistance in root maggots and can trigger outbreaks of other insect pests, like aphids and caterpillars, by killing their natural enemies. Therefore, we cannot recommend using foliar sprays that specifically target adult root maggot flies.

For the most up-to-date information on insecticides registered against the sugar beet root maggot in Idaho, consult the following Pacific Northwest Pest Management Handbook: <https://pnwhandbooks.org/insect/agronomic/sugar-beet>.

## Additional Reading

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**Trade Names**—To simplify information, trade names have been used. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

**Groundwater**—To protect groundwater, when there is a choice of pesticides, the applicator should use the product least likely to leach.