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Biology and Management of the Potato Tuberworm in the Pacific Northwest

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The potato tuberworm, *Phthorimaea operculella* (Zeller), is a pest of many solanaceous crops, including potatoes. Commonly found in tropical and subtropical regions throughout the world, potato tuberworm (PTW) is one of the most important constraints to potato production worldwide. Larvae of this species mine leaves, stems, and petioles and excavate tunnels through potato tubers (Figure 1).

Adequate control of PTW is critical because larval infestation of tubers renders potatoes unmarketable. There is zero tolerance for the presence of tuberworm larvae in raw processing product because they are classified as foreign material. Additional losses are likely from infested tubers that rot in storage or from spread that may occur early in the storage season.

Figure 1. Potato tuberworm larva. Photo: University of California

These losses are of particular concern in the Pacific Northwest, where large quantities of potatoes are stored.

The pest is difficult to control, and many farmers in other parts of the world have relied extensively on the use of insecticides for PTW control. Protecting potatoes in an integrated manner is essential to the production of a high-quality crop without PTW damage.

The potato tuberworm in the Pacific Northwest

Although PTW was recorded in California as early as 1856, it was first reported in the Pacific Northwest (in Washington) by Chittenden in 1913. There was no further evidence of PTW in the Pacific Northwest until 2000 and 2001, when tubers suspected to have been damaged by PTW were found in Oregon. However, PTW was not a major concern for growers in the Columbia Basin potato production region until 2002, when a field with severe tuber damage was documented in northeastern Oregon.

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In 2003, potatoes from several fields in the Columbia Basin of Oregon were rejected for market due to PTW infestation, resulting in an economic loss of about $2 million. By 2004, large numbers of the insect were confirmed by pheromone trapping in Umatilla and Morrow counties (Oregon)—the southernmost region of the Columbia Basin potato production area—and in southeastern Washington.

Economic losses increased substantially in 2004 and 2005 due to increased PTW densities in areas already infested, range expansion, tuber damage, and the cost of control measures. In those 2 years, the pest's range expanded 140 miles north into Washington, including Benton, Franklin, Adams, Grant, and Lincoln counties. In Oregon, PTW has spread beyond Umatilla and Morrow counties to western, central, and eastern Oregon potato production areas, including Washington, Multnomah, Jefferson, Crook, Klamath, Union, Baker, and Malheur counties (Figure 2), although no damage has been reported in these areas. In addition, PTW has been confirmed in at least three counties in western Idaho (Canyon, Payette, and Elmore counties); however, only adults have been observed, and no foliar or tuber damage has been detected.

Distribution and hosts

Potato tuberworm has been reported in tropical and subtropical areas in South, Central, and North America; Africa; Australia; and Asia. In the United States, PTW has been reported in California, Arizona, Maryland, Virginia, Colorado, North Carolina, South Carolina, New York, North Dakota, Oregon, Washington, and Idaho.

Besides potato, PTW has been reported to infest other solanaceous plants such as tomato, pepper, eggplant, tobacco, and nightshade. In the Pacific Northwest, PTW has been found infesting only potatoes.

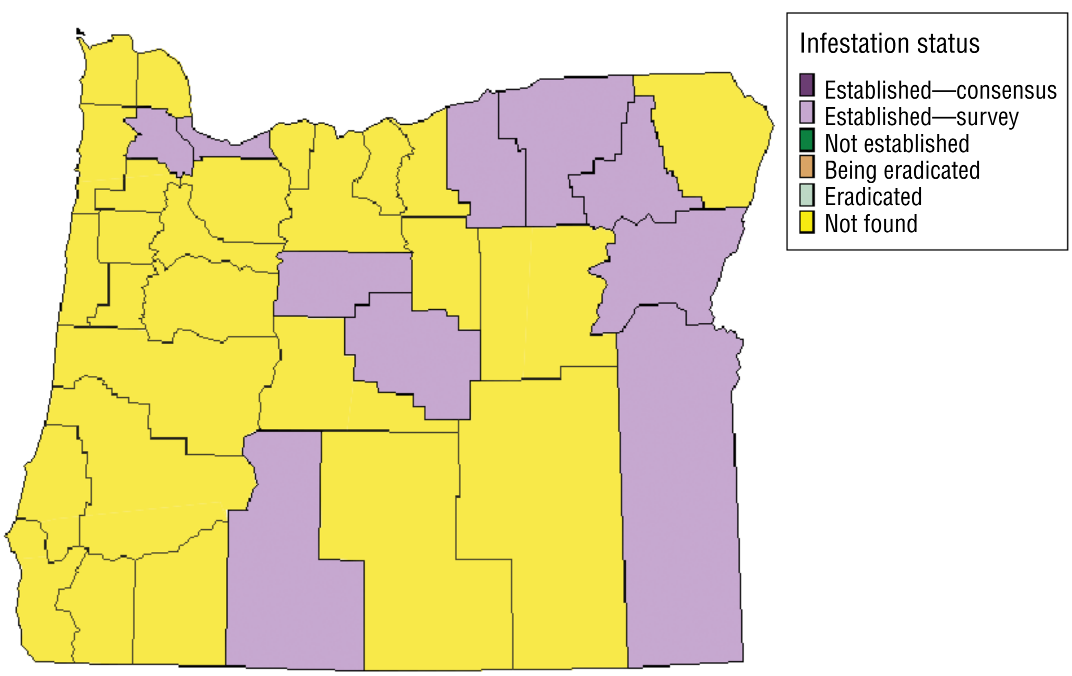

Figure 2. Reported distribution of the potato tuberworm in Oregon. Data retrieved from the National Agricultural Pest Information System on March 15, 2006.

Identification and biology

PTW has four life stages: adult, egg, larva, and pupa. Adults are small moths (approximately ⅜ inch long) with a wingspan of approximately ½ inch. Forewings have dark spots (two to three dots on males and a characteristic "X" pattern on females) (Figure 3). Both pairs of wings have fringed edges (Figure 4).

Females lay their eggs on foliage, soil, plant debris, or exposed tubers. Moths can crawl through soil cracks or burrow short distances through loose soil to find tubers on which to deposit eggs.

Eggs are less than 0.02 inch, spherical, translucent, and ranging in color from white or yellowish to light brown (Figure 5). Larvae usually are light brown with a brown head (Figure 1, page 1). Mature larvae (approximately ⅜ inch long) may have a pink or greenish color.

Larvae feed on leaves throughout the canopy but prefer the upper foliage. They mine the leaves, leaving the epidermal areas on the upper and lower leaf surface intact. Larval feeding results in necrotic areas on leaves. Leaf damage is unremarkable and not always visible without careful scouting. Larvae close to pupation drop from infested foliage to the ground and may burrow into tubers. Exposed tubers are most vulnerable to PTW damage (Figure 6). Larvae can move via cracks in the soil.

Ultimately, larvae spin silk cocoons and pupate on the soil surface or in debris under the plant. Pupae occasionally are found on the surface of tubers, most commonly associated with indentations on the tuber eyes, but they usually are not found inside tubers. PTW pupae (approximately ⅜ inch long) are smooth and brownish (Figure 7) and often are enclosed in a covering of fine sediment.

Figure 3. Potato tuberworm female (left) and male (right). Photo: S.I. Rondon, Oregon State University

Figure 4. Both pairs of wings have fringed edges. Photo: Oregon Department of Agriculture

Figure 5. Potato tuberworm eggs are small, spherical, translucent, and range in color from white or yellowish to light brown. Photo: S. DeBano, Oregon State University

Figure 6. Exposed tubers are predisposed to tuberworm damage. Photo: S. DeBano, Oregon State University

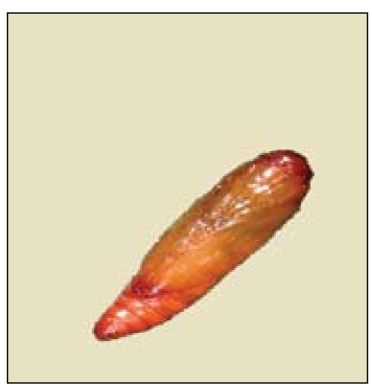

Figure 7. Tuberworm pupae are smooth and brownish. Photo: International Potato Center

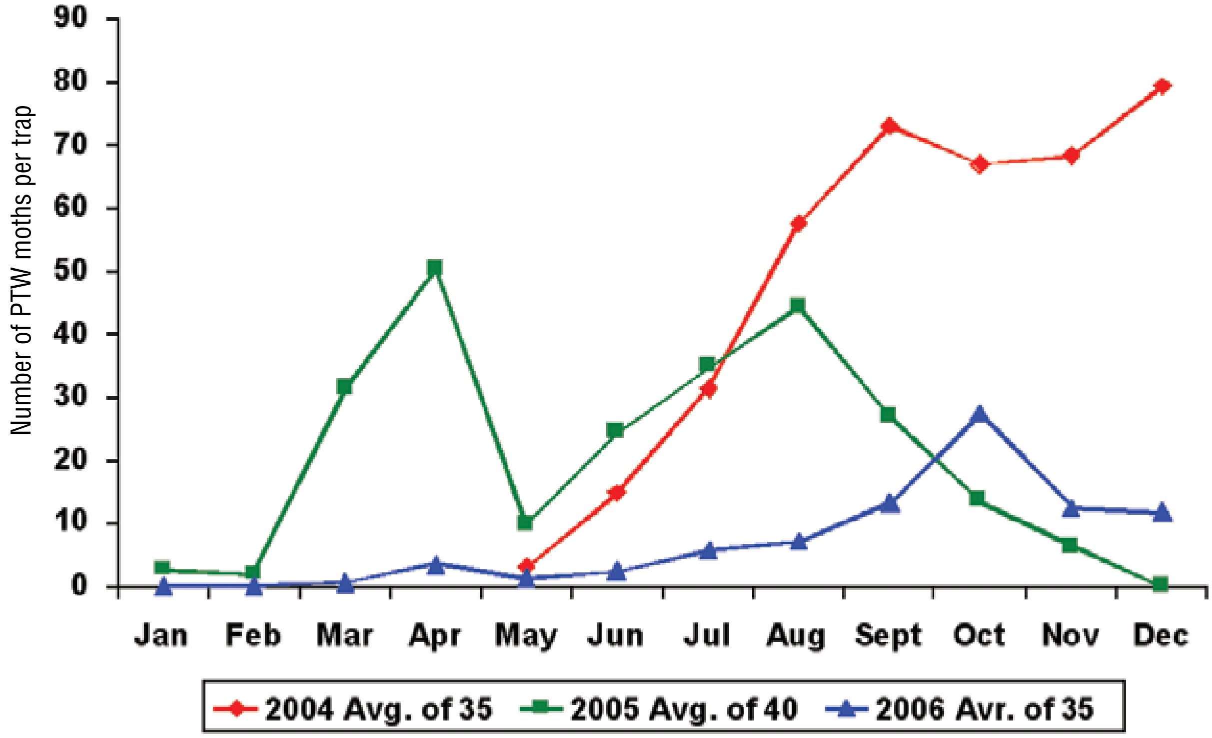

Figure 8. Population dynamics of the potato tuberworm in northeastern Oregon, 2004–2006.

Preliminary studies in Oregon indicate that PTW adults potentially can emerge from soil at depths up to 4 inches. Once adults emerge, mating occurs. Within a few hours, depending on temperature, females seek a host on which to lay eggs.

Studies in Maryland and Virginia indicated that PTW can survive subfreezing temperatures. In the Columbia Basin of Oregon, trapping data from spring 2004 to fall 2005 showed that PTW males were present every week except one (in mid-January), with the highest numbers per trap occurring in December (Figure 8).

It is unknown where PTW overwinter in the lower Columbia Basin. PTW eggs, larvae, and pupae can potentially survive in or near cull piles, potato tubers left in the soil after harvest, or volunteer potatoes late in the season. PTW is known to survive as pupae in the soil.

Trapping data suggest that PTW is capable of producing at least two or three generations per year in the Columbia Basin.

Monitoring

Trapping

Researchers, crop consultants, and growers in Oregon, Washington, and Idaho are monitoring the presence of PTW. Growers in areas potentially impacted by this insect are encouraged to monitor insect numbers using pheromone traps (Figure 9). Pheromones are concentrated quantities of the female “scent.” Male moths are attracted by a pheromone-impregnated rubber septum in a sticky liner inside the trap.

Figure 9. Delta trap. Photo: S.I. Rondon, Oregon State University

The recommendation is to place at least one trap per potato field, beginning after canopy closure. Since other insects, including other Gelechiidae moths, can be trapped in the liners (Figure 10), change liners once a week for easy viewing of moths. Lures usually should be changed monthly but may last longer, depending on environmental conditions. Cooler temperatures increase the longevity of lures.

Treatment levels have not been established for Oregon and Washington. California recommends a threshold of 15 to 20 moths per trap per night. However, remember that PTW populations vary greatly from field to field and from area to area. **Management recommendations should be based on field-specific information.**

Field scouting for foliar damage

Most economic damage occurs when PTW infests potato tubers, but heavy foliage infestation may also cause yield losses. When significant green foliage is available, larvae prefer to feed in the foliage, rather than in tubers. Thus, you may want to complement pheromone trapping with field scouting for foliage damage.

Sample at least 10 plants per field or circle. Individual plants may be examined for the presence or absence of PTW damage, rather than quantifying the amount of damage per plant.

Nearly 55 percent of PTW mines are found in the upper third of the potato plant. Mines are not easily found, so look carefully.

Region-wide trapping

Since 2004, a pheromone trapping network has been deployed in the Columbia Basin of Oregon and Washington to assess and document the distribution and spread of PTW. In 2005, traps were also deployed in Idaho. For current information, visit the following websites:

- **Oregon** (Hermiston Agricultural Research and Extension Center, Oregon State University): http://oregonstate.edu/Dept/hermiston/TrapReports.php
- **Washington** (Washington State Potato Commission): http://www.potatoes.com/research.cfm
- **Idaho** (Idaho Department of Agriculture): http://www.agri.state.id.us/

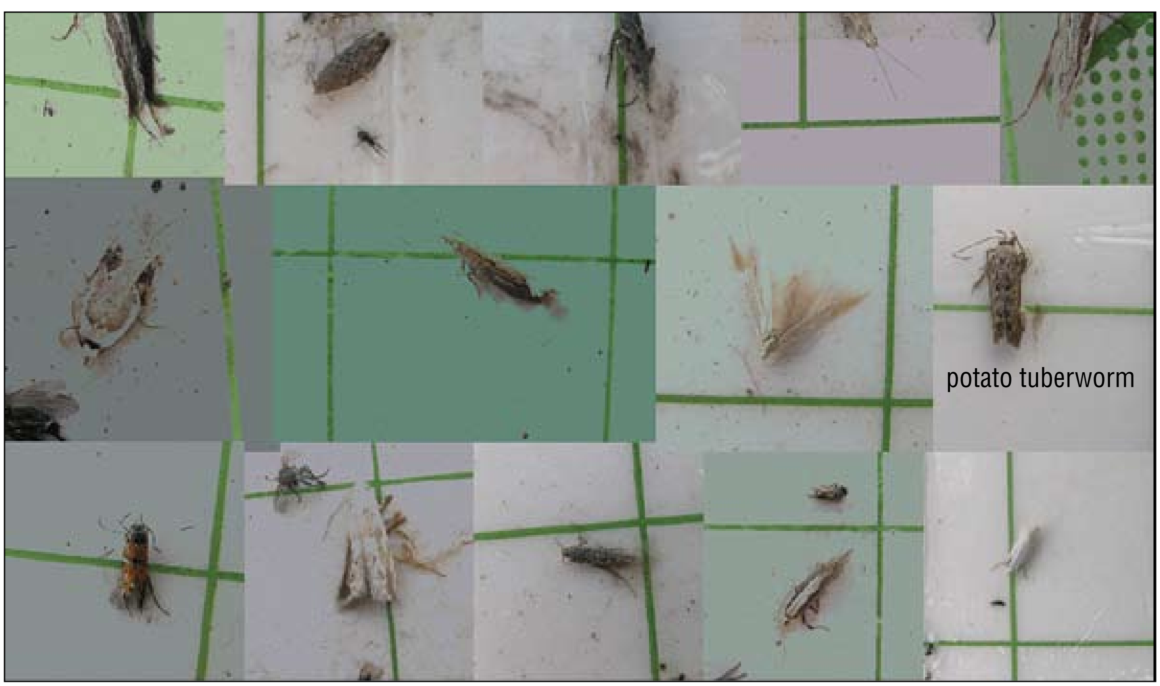

Figure 10. Potato tuberworm moth and various non-tuberworm moths captured in delta traps.
Photo: A. Jensen, Washington State Potato Commission

Control methods

The most effective management program combines cultural, biological, and chemical approaches. A number of insecticides have proven effective in controlling PTW. Since this pest prefers foliage rather than tubers, and tuber infestation is reduced when a full or partial canopy is present, early use of insecticides may not be warranted.

Cultural control

Cultural methods reported to reduce PTW include the following.

Elimination of cull piles and volunteers. Eliminate cull piles and volunteer potatoes to reduce overwintering stages, which are a source of next year's populations (Figure 11).

Soil moisture at and after vine kill. Keeping the soil moist via overhead irrigation prevents soil cracking. This is especially important later in the season when vines are beginning to die. In research at Oregon State University, applying 0.1 inch of water daily through a center pivot irrigation system from the time of vine kill until harvest decreased PTW tuber damage and did not increase fungal or bacterial diseases. The daily irrigation probably closed soil cracks, reducing tuberworm access. PTW also may have died from soil oxygen reduction due to water saturation, and/or their mobility may have been reduced by wet soil, decreasing their ability to find a tuber to infest.

Length of time between desiccation and harvest. Field observations support the premise that PTW prefer green foliage to tubers for egg laying and feeding. When foliage starts to decline, tuber infestation increases. Adults move into the soil via soil cracks to find shelter from the light and to lay eggs on tubers, while larvae do so to find food. Thus, the length of time between desiccation and harvest is crucial. The longer dead vines and undug tubers remain in the field, the greater the likelihood of tuber infestation.

Rolling or covering hills. Tubers that are exposed or close to the surface are at high risk for PTW damage. Do everything possible to maintain more than 2 inches of soil over the tubers during the season. Covering hills with 1 to 2 inches of soil immediately after vine kill significantly reduces tuber infestation (Figure 12). A rotary corrigator can be used.

Figure 11. Elimination of cull piles reduces tuberworm infestation. Photo: S.I. Rondon, Oregon State University

Figure 12. Covering hills with soil immediately after vine kill significantly reduces tuber infestation. Photo: P. Hamm, Oregon State University

Research at Oregon State University found that rolling of potato hills in sandy soil caused soil to slough off the hill, resulting in increased PTW damage. Thus, rolling is not recommended in areas with sandy soils.

Cultivar selection. Varietal selection offers some opportunity to reduce PTW damage. Varietal differences in susceptibility to PTW damage may be due to differential feeding by larvae or to adult egg-laying preferences. Also, varieties that are set deeper in the hills have less potential for tuber infestation.

More than 120 cultivars have been tested in the Columbia Basin, and levels of PTW tuber damage have differed among cultivars. More research is pending. In the future, cultivar selection may be a way to reduce PTW damage.

Chemical control

Insecticide application after vine kill. Research at Oregon State University found that applying insecticides at and after vine kill almost always reduced PTW damage in tubers. The use of insecticides prior to vine kill is discussed below under pesticide timing.

Pesticide screening and recommendations. Many insecticides have been tested for efficacy for controlling PTW. In 2005 and 2006, insecticides or combinations of insecticides applied by ground sprayer or chemigation were tested at the Hermiston Agricultural Research and Extension Center in Oregon and at the USDA-ARS research site near Paterson, WA (trials by Agriculture Development Group, Inc.).

Products that have been found to be effective for control of PTW in Oregon and Washington are listed at http://insects.ippc.orst.edu/pnw/insects.

Pesticide timing. Timing of insecticide application to reduce tuber damage is an important question. In 2005, trials in the Columbia Basin tested three insecticides (Asana, Monitor 4, and Lannate LV), applied at different intervals (from 1 to 4 weeks) before vine kill. All insecticide treatments significantly reduced tuber damage. There was no advantage to beginning control efforts earlier.

This research involved potatoes that were chemically killed. Practices for fields that are allowed to die naturally have not been adequately addressed. In these fields, tuber infestation could occur as the canopy opens slowly over a long time period. In this case, the effect of dying foliage on tuber infestation probably is related to the gradual loss of foliage as a feeding site for the larvae.

Recommendations

General

- Develop a monitoring program based on trapping and field scouting during the growing season to gauge the potential threat of PTW in each field.
- If PTW pressure is high (California's threshold is 15 to 20 moths per trap per night), a control program beginning 1 month prior to harvest is suggested.
- Keep soil moist between vine kill and harvest.
- Use an effective chemical product (see http://insects.ippc.orst.edu/pnw/insects).

Potatoes that are vine killed

- Develop a monitoring program for the month before desiccation.
- As part of a complete PTW control program, include an insecticide application at or near desiccation.
- Minimize the time between desiccation and harvest. Do not leave tubers in the ground longer than necessary.

Potatoes that are allowed to die down naturally

- Develop a monitoring program for the month before harvest.
- Begin applying insecticides when areas of the field begin to die naturally. The importance of this practice needs further investigation.
- Include an insecticide application near harvest. Check the preharvest interval carefully.

Biological control

One of the first assessments for a successful integrated pest management program, following establishment of a monitoring program, should be to determinate the role of natural enemies. Parasitoid wasps such as *Copidosoma* spp. and *Apanteles* spp. are important in PTW control in other parts of the world. A few parasitoid wasps have been collected from PTW in the Pacific Northwest, but the importance of parasitoids in potato fields is unknown. Also unknown is the role of common predators such as lady beetles, big-eyed bugs, and ground beetles in controlling PTW. Choose insecticides that preserve natural enemies.

Insect diseases caused by bacteria, viruses, and nematodes have been developed to control insect pests, including PTW. Microbial control of PTW is not yet developed for commercial use, but has potential in the future.

For more information

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