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Potato Psyllid Vector of Zebra Chip Disease in the Pacific Northwest

Biology, Ecology, and Management

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Zebra chip (ZC) is a destructive disease of potatoes emerging in North America and other parts of the world. The disease has been very costly to manage in potato crops and has caused millions of dollars in losses to the potato industry in the southwestern United States, particularly Texas.

ZC was first recorded in Idaho and the Columbia Basin of Washington and Oregon late in the 2011 growing season. This area produces more than 50 percent of the potatoes grown in the United States, so the presence of ZC in the region has the potential to be economically devastating.

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Figure 1. Potato psyllid adult.

Brief history and distribution of ZC

ZC was first documented in potato fields around Saltillo, Mexico in 1994. In the early 2000s, the disease was reported in southern Texas, and by 2006 ZC had spread to all potato production areas in Texas. Since then, ZC has been found in Arizona, California, Colorado, Kansas, Nebraska, Nevada, New Mexico, Wyoming, Oregon, Washington, and Idaho. ZC is also found in Guatemala, Honduras,

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Contents

Mexico, New Zealand, and more recently Nicaragua (Figure 2).

The bacterium

The pathogen associated with ZC is the bacterium *Candidatus* Liberibacter *solanacearum* (a.k.a. *Ca*. L. *psyllaurous*), vectored to potato by the potato psyllid, *Bactericera cockerelli* (Šulc) (Hemiptera: Triozidae) (Figure 1, page 1).

Members of the '*Ca*. Liberibacter' group are vectored by at least five psyllid species associated with important diseases of citrus, solanaceous crops, and carrot. *Ca*. L. *asiaticus*, *Ca*. L. *africanus*, and *Ca*. L. *americanus* are associated with citrus greening and are vectored by the Asian citrus psyllid (*Diaphorina citri* Kumayama) and African citrus psyllid (*Trioza erytreae* Del Guercio). *Ca*. L. *solanacearum* severely affects carrot crops in Europe and is transmitted by the carrot psyllid *Trioza apicalis* Foerster in northern Europe and *Bactericera trigonica* Hodkinson in the Mediterranean region.

Detection of the '*Ca*. Liberibacter' is based on polymerase chain reaction (PCR) amplification. In potatoes, the bacterium affects the phloem tissue, causing foliar and tuber symptoms (see "Damage from vectors," page 4) including higher than normal sugar concentrations in tubers.

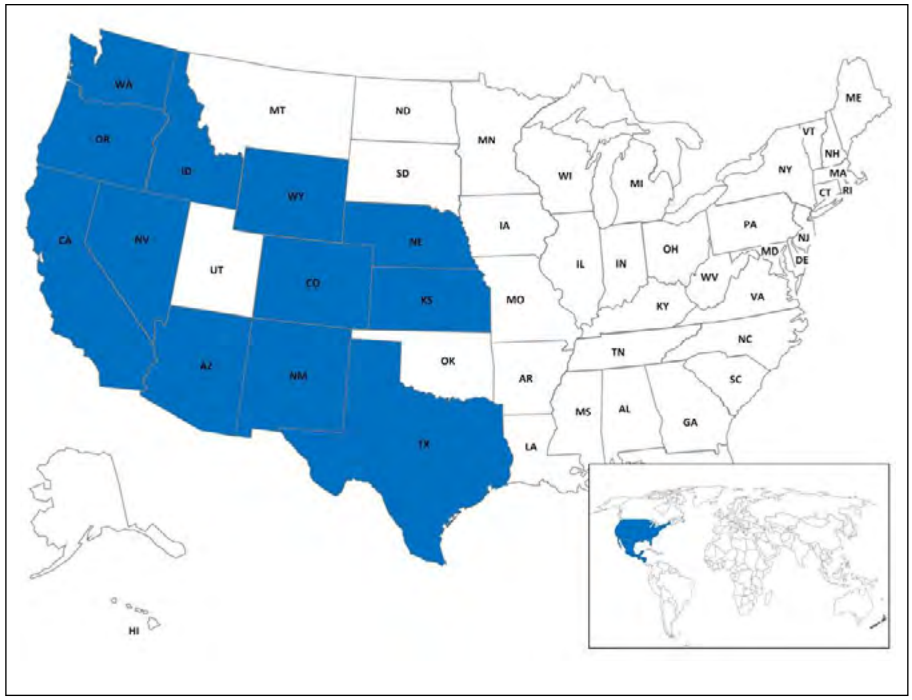

Figure 2. Distribution of ZC in the United States.

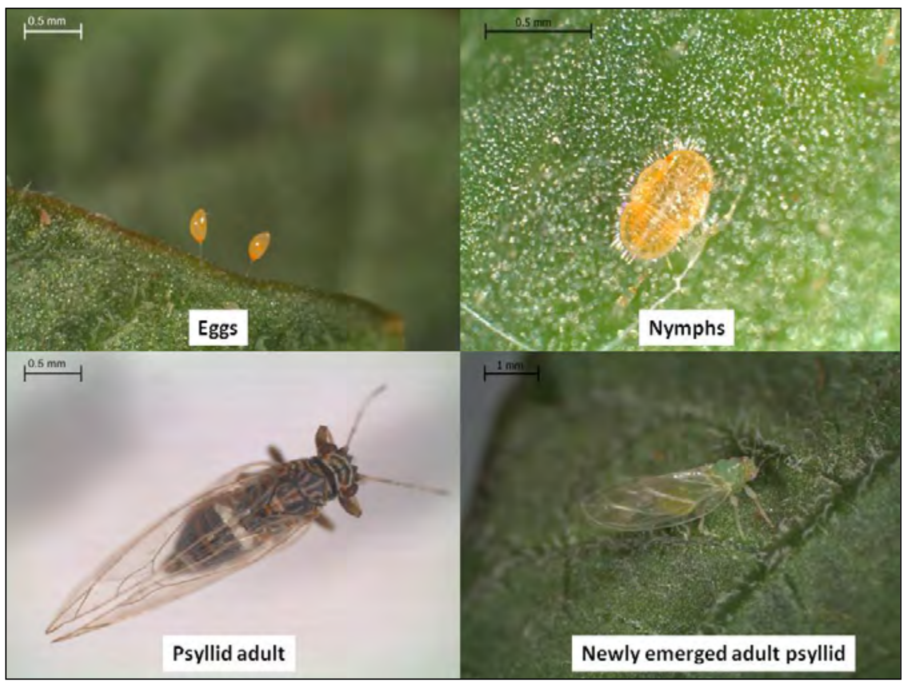

Figure 3. Life stages of the potato psyllid.

Biology of the vector

The potato psyllid is a phloem-feeding insect that has an extensive host range but reproduces mainly on potatoes (*Solanum tuberosum* L.) and other members of the nightshade family (Solanaceae) including tomatoes (*Solanum lycopersicum* L.). Plants from the family Convolvulaceae (bindweeds) are also able to support the normal development of the psyllids.

Potato psyllids pass through three life stages: egg, nymph, and adult (Figure 3). The insect can complete a generation in less than a month under optimal conditions.


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Figure 4. Late instar of a potato psyllid. Note the "wing pads."

Eggs

The football-shape eggs (Figure 3, page 2) are extremely small, just slightly larger than potato leaf hairs. Eggs are yellow-orange and are attached individually to leaves on a short stalk. They are usually laid in the plant canopy on the underside and along the edges of leaves. A hand lens with at least 10× magnification is required to see them.

Eggs hatch in 6 to 10 days, depending on temperature. Warmer temperatures favor early hatching, although temperatures above 90°F (32°C) reduce reproduction and survival.

Nymphs

Psyllid nymphs are flat and green with a fringe of short spines around the edge of the body. Larger nymphs have distinct "wingpads" on their dorsum. In warm temperatures, immature psyllids go through five stages in as few as 13 days.

Nymphs (Figure 4) look like immature soft scale insects or whiteflies. In contrast to whiteflies or scales, psyllid nymphs move readily when disturbed.

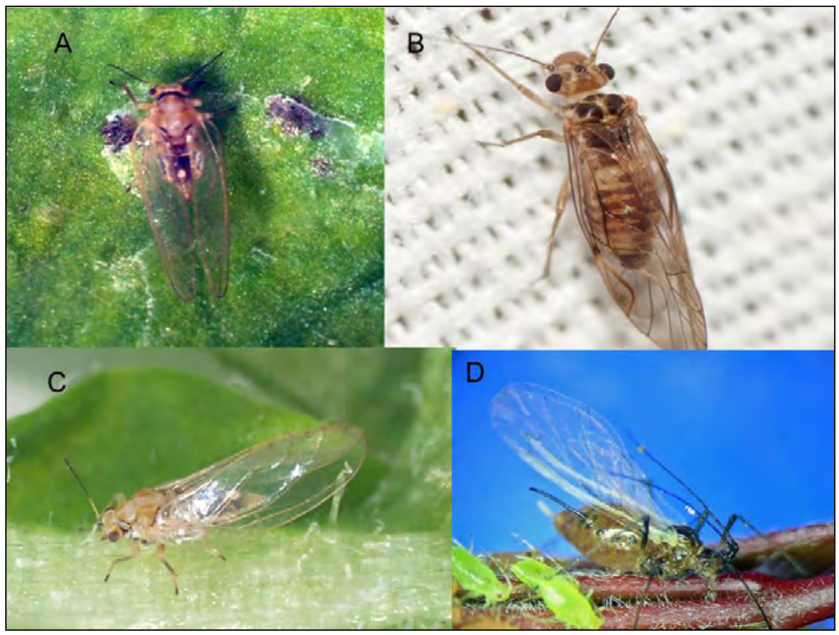

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Figure 5. "Look-alike" insects that are also trapped on cards: (A) psyllid; (B) bark louse; (C) psyllid; (D) winged aphid.

Adults

Psyllid adults are about 0.08 inch (2 mm) long and have clear wings that rest roof-like over the body. They are closely related to aphids and leafhoppers and resemble small cicadas, winged aphids, or bark lice (Figure 5).

The potato psyllid is predominantly black with white markings. The first abdominal segment shows a broad white band and the last segment has an inverted white V. Newly molted adults are difficult to distinguish from other insects (Figure 6, page 4). Adult psyllids jump readily when disturbed.

Once the insect, adult or nymph, acquires the bacterium (from feeding on an infected plant), it is always a carrier of the bacterium. A percentage of the young hatching from eggs laid by an infected adult become carriers of the bacterium as well.

Overwintering

Potato psyllid has long been known to be present throughout the Pacific Northwest (PNW). It was thought that psyllids are unable to overwinter in the area and that reintroduction in any given season required migration on air currents from the south, possibly from California. However, observations by co-author Jensen in 2011–2012 (December through

March) suggest that adult psyllids can survive the winter in certain areas of this region (Figure 7).

Psyllid eggs were found on *Solanum dulcamara* L. (also called bittersweet nightshade, bitter nightshade, blue bindweed, or poison berry, among other common names). This is a perennial weed native to Eurasia, found in fencerows, pond margins, low woods, and roadsides throughout the PNW (Figure 8, page 5). Preliminary research shows that potato psyllids can overwinter in the PNW, but more research is needed to confirm whether or not overwintering populations can harbor the bacterium. The insect is known to overwinter from California to southern Texas and northern Mexico.

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Figure 6. Newly molted potato psyllid adult.

Erik Wenninger, University of Idaho. Used by permission.

Figure 7. Bittersweet nightshade early in the spring in the Pacific Northwest. "Dead vines" can still host psyllids.

Damage from non-vector psyllids

Psyllid nymphs and adults feed similarly to aphids, by probing host plants with their needle-like mouthparts and sucking plant juices. Because they feed directly on the plant, **potato psyllids can cause plant damage even when not carrying the bacterium responsible for ZC**.

As they feed, psyllids inject toxins with their saliva that can cause leaf yellowing or purpling, smaller and fewer tubers, and misshapen tubers. This described physiological condition is called "psyllid yellows" (Figure 9, page 5) and is generally less damaging than ZC, as it does not cause the characteristic ZC symptoms seen in the cut tuber or following frying.

Damage from vectors

ZC usually requires about 3 weeks following pathogen inoculation by psyllids to produce symptoms in the foliage and tubers (Figure 10, page 6). Plants infected by ZC exhibit a range of aboveground symptoms that are similar to potato purple top and psyllid yellows, including stunting, chlorosis, leaf scorching, swollen internodes near apical portions, axillary bud and aerial tuber proliferation, necrosis of vascular system, and early death.

Symptoms in tubers include development of dark striped patterns of necrosis (Figure 11, page 6). The disease also alters the starch metabolism of infected tubers, converting starch into sugars in random zones of the tuber.

The name "zebra chip" refers to the characteristic brown discoloration of the vascular ring and medullary ray tissues within the tubers that is amplified when tubers are sliced and fried into chips or French fries (Figure 12, page 7). Though the defect is harmless to consumers, the flavor of the product is altered, making infected tubers unmarketable. In addition to reducing tuber quality, ZC can cause significant yield reduction.

While there are differences in susceptibility across potato varieties, virtually all available commercial varieties will express symptoms of ZC on the foliage or tubers or both.

Management

Psyllids are typically first detected in PNW potatoes in early July (Figure 13, page 7), but the timing of the ZC outbreak in 2011 suggests that psyllids carrying the bacterium ("hot psyllids") first colonized the potato fields around mid-June. It is suggested that colonization was later in Idaho. With these points in mind, consider the following management recommendations.

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Figure 8. Bittersweet nightshade late in the spring in the Pacific Northwest.

Sampling

A sampling program to monitor psyllid populations is a fundamental tool for a successful integrated pest management program. Sampling programs are critical for decision-making strategies.

- **Yellow sticky cards.** Unbaited yellow sticky cards are recommended to detect the first occurrence of psyllid in the area (Figure 14, page 8), though their sensitivity to confirm psyllids at low population (early in the season) may be low. Start seasonal sampling as soon as the potato season starts. Replace sticky cards weekly.

  Sticky traps will likely be most useful for detecting psyllid migration into and out of fields. Spatial and temporal studies indicate that both psyllid abundance and ZC incidence progress faster on the edges than in the infields early in the season. In California, over 80 percent of the potato psyllids can be found on the field edges early in the season.

  As the season progresses, psyllids become more evenly distributed throughout the field. **Placement of cards outside of fields, such as is recommended for beet leafhopper, is not effective for monitoring potato psyllids. Sticky cards have to be inside the field**.

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Figure 9. Psyllid yellows foliar symptoms.

Texas recommendations include the use of at least five yellow sticky cards such as those used for beet leafhopper **but in the field** (Figure 15, page 8). Place sticky cards inside the circle to catch psyllids. The more cards per field, the more likely you are to detect psyllids. Sticky cards to catch beet leafhopper are placed outside the circle.

- **Sweep net and aspirator.** Considering that adult potato psyllids are active and fly or jump away when disturbed, a sweep net plus an aspirator or DVAC (inverted leaf blower) are also recommended. Texas recommends 100 sweeps from around the field perimeter. If you use a DVAC, be sure to use it 5 to 10 feet from the field edge for at least 5 minutes. It is slightly more difficult to sort psyllids collected by these methods than to count them on a sticky card.

  For more information on using a sweep net, see http://oregonstate.edu/dept/hermiston/silvia-rondon.

Silvia Rondon. © Oregon State University.

Figure 10. Sequence of infection: Week 1, wrinkled leaves, purple top, etc; Week 2, foliar collapse; Week 3, plant dead.

- **Leaf sampling.** Collect 10 leaves from 10 locations among the 10 outer rows of the field (Figure 15, page 8). Collect full-size leaves from the middle of the plant to look for psyllid eggs or nymphs (Figure 16, page 8). A hand lens is required to see these life stages.

  The nymphs reside on the underside of the leaf. Eggs are most commonly present on the leaf's edges and underside. However, if the psyllid population is high, eggs can be found everywhere.

  Keep in mind that this is not the preferred method for determining the first occurrence of these insects. Leaf sampling confirms that psyllids are already colonizing the field, and ZC infection will likely have happened by then if the psyllids are carriers of the bacterium.

Action threshold

No action threshold exists for psyllids in potato. Until more is known, we suggest that **the threshold for action is detection of potato psyllids at any level, in any life stage**.

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Figure 11. Typical pattern of necrosis in potato tubers.

To determine a more specific action threshold, more information is needed regarding:

- Better trapping methods to help determine potato psyllid populations
- Biology of overwintering psyllid populations in our region

- Whether the bacterium can overwinter in our region, either in potato psyllids, volunteer potato, or weed hosts

In 2011, some growers in the Columbia Basin and southwest and central Idaho faced low ZC damage (1 to 2 percent) even though they did not see psyllids in their fields. This indicates the difficulty both in trapping psyllids when the populations are low and in keeping fields free of ZC when relying on trapping data.

Joseph Munyaneza, USDA-ARS. Used by permission.

Figure 12. Stripes in fry tubers.

Non-chemical control

There are no effective non-chemical control tactics for potato psyllids, although research is underway in this area.

Chemical control

There are a number of insecticides registered on potatoes that have activity against potato psyllids in the adult and/or immature stages. Some insecticides with activity against adults and nymphs will also have activity against the eggs.

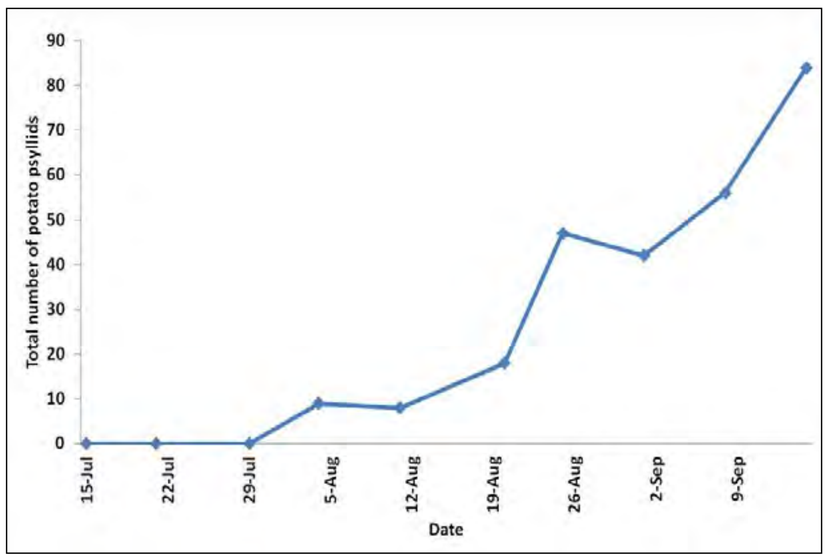

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Figure 13. The potato psyllid in the Columbia Basin of Oregon. Before 2011, psyllids were not detected before mid-July.

Season-long, weekly applications are used in areas where ZC has been problematic (e.g., in Texas, psyllids are present there from planting to harvest). At this point, PNW recommendations are not expected to follow the same lengthy period of control since psyllids are not thought to be in potato fields in the early part of the season. You can search information regarding chemical control options at http://potatoes.com/Research.cfm and http://insects.ippc.orst.edu/pnw/insects.

Resistance management

The risk of insects developing resistance to insecticides can be reduced with adequate planning. **Be sure to follow insecticide resistance management plans**.

In the PNW, the first psyllid life stage detected is usually the adult. Some insecticides have activity against adults, while others do not. In psyllid control programs in other states, when adults are detected, it is recommended that a product with activity against adults be used first.

There are some anecdotal reports that imidacloprid products are no longer effective against psyllids, but this potential problem needs further investigation.

Storage

There is little information available on the biology of the disease in storage. However, there is research that shows that asymptomatic tubers produced by potato plants infected late in the season may later develop ZC symptoms in storage. Apparently, there is "movement" of the bacteria from the stolon end to the bud end as storage season progresses, and therefore internal symptoms continue to develop throughout the tuber with time.

Preliminary observations showed that naturally-infected, low ZC incidence at harvest (1 to 2 percent) did not show an increase in incidence in storage, but additional studies are warranted. Movement of the bacterium from infected to healthy tubers in storage has not been documented.

Experience with this disease in some locations suggests that infected tubers do not rot in storage. Tubers infected with the bacterium may be more susceptible to shatter bruising.

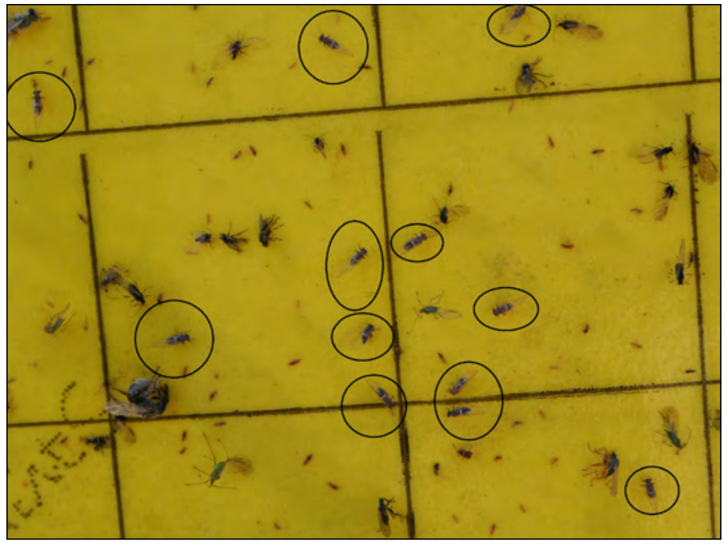

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Figure 14. A yellow sticky card showing potato psyllids (circle).

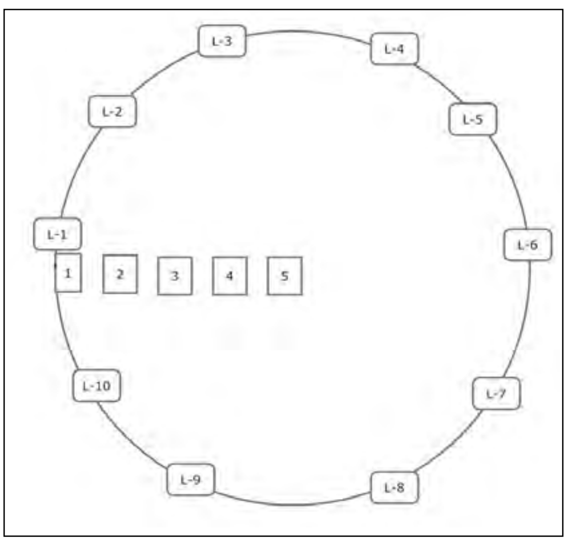

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Figure 15. Deployment of sticky cards in the field. Texas sampling method. L = location of leaf sampling.

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Figure 16. Leaf samples.

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