Potato Zebra Chip

Background

The PROCINORTE Plant Health Task Force (PHTF) is an international group of researchers from Canada, Mexico and United States of America. The PHTF addresses priority themes to avoid technical barriers to trade between the three countries, focusing on plant health. This document was developed to provide updated information to producers/growers, industry associations and interested stakeholders regarding the bacterial pathogen *"Candidatus* Liberibacter solanacearum" (Lso) in the Americas.

Lso causes diseases in solanaceous crops (potatoes, tomatoes, peppers and related species), such as the well-known zebra chip disease in potatoes. These diseases are characterized by foliar dieback and result in yield and quality losses. The pathogen has been documented in western United States, Mexico, southern Alberta in Canada, Central America and New Zealand. Lso is transmitted by the potato psyllid *Bactericera cockerelli*, a flying insect that measures 2-3 mm.

Pathogen

Crop host plants

Lso causes disease symptoms in solanaceous crops including potatoes (zebra chip), eggplant, tomato (permanente del tomate), peppers (variegado de chile), tobacco, tomatillo and ground cherry.

Potato plant showing typical zebra chip symptoms, including rolling up and stunting and purple discoloration at the top of the leaves. Credits Joe Munyaneza, USDA-ARS.

Common above-ground plant symptoms across crops include flower abortion, leaf cupping/ curling, chlorosis and plant decline.

In tomato, additional symptoms include variegated leaf color, purpling of leaves and large internodes. Smaller deformed fruits are also observed. In pepper, interveinal chlorosis and deformed fruit are the predominant symptoms. In potato, there is often aerial tuber formation and purpling of upper leaves.

Aerial (above ground) tuber formation on an Lso-infected potato plant. Credits Sergio Sánchez, UAAAN-INIFAP, México.

Lso-infected potato plant. Credits Sergio Sánchez, UAAAN-INIFAP, México.

The disease severely disrupts carbohydrate flow in potato plants, creating a striped internal appearance in cut tubers. Symptoms are even more pronounced in fried potato chips.

Tubers infected with zebra chip disease show dark, stripe-like symptoms in the tissue. The damage becomes even more pronounced when the potatoes are made into chips or fries. Credits Credits Joe Munyaneza, USDA-ARS.

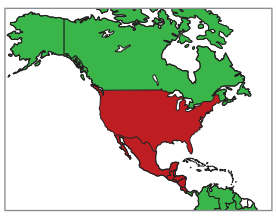
Tuber stem ends are often sunken with minor cracking along the surface.

Tubers infected with zebra chip with cracking and sunken along the surface. Credits Joe Munyaneza. USDA-ARS.

Early season infection in potatoes leads to significant yield loss and symptom development. Late season infection may not significantly affect yield, but symptoms still can develop in stored potatoes.

Zebra chip symptoms in potato slices from infected tubers in uncooked (left) and fried chips (right). Credits Joe Munyaneza, USDA-ARS.

Zebra chip disease was first reported in Mexico in the 1990s. The pathogen is now widespread in solanaceous crops in Mexico, particularly in eastern regions. Since the first reported outbreak in Mexico, the pathogen has expanded its geographic range to include central and western United States and Central American countries. In 2017, a single infected potato was found in southern Alberta, Canada (See map). Lso is transmitted by the potato psyllid (Bactericera cockerelli)



Geographic distribution of Lso in America. Modified from Joe Munyaneza. USDA ARS

in North and Central America. The pathogen is spread primarily when the psyllid acquires Lso from infected plants and then feeds on an uninfected plant. Although psyllid transmission is the primary route of infection, other forms of transmission have been suggested. Tuber seed piece transmission appears to be insignificant under field conditions, although it is unclear what role volunteer plants from infected tubers may play. At present, it is also unclear whether transmission can occur via a true seed.

Given the fact that this bacterium cannot be cultured on artificial media, specialized detection methods are required to identify it. The presence of zebra chip striping on sectioned tubers as described above is a good indicator of potato infection by Lso. Suspicious samples should be forwarded to a local diagnostic laboratory for identification.

Vector

The potato psyllid lifecycle includes the egg, nymph and adult stages. Development from egg to adult is completed in less than a month during a typical growing season. Females can lay over 200 individual oval-shaped eggs that are very small, orange and located on leaf margins or stems.

Nymphs are wingless, yellow to green in color, and their shape is flat and round or oval. The nymphs develop through five instars that increase in size at each stage and feed primarily on the underside of leaves. They have only localized mobility and are largely confined to host plants—unlike the adults, which are highly mobile in the landscape.

New psyllid (*Bactericera cockerelli*). Credits Dan Johnson. U. Lethbridge, Canada.

Immature psyllid (*Bactericera cockerelli*). Credits Dan Johnson. U. Lethbridge, Canada.

Adults of the potato psyllid (*Bactericera cockerelli*). Credits Dan Johnson. U. Lethbridge, Canada.

Newly emerged adults are yellow to green and usually acquire the dark adult coloration within one day. Mature adults are black and white with tent-like wings. Defining markers are black and white stripes below the head, three-branch wing venation and white stripes on the abdomen. Adults are extremely mobile, jump when disturbed, and can fly long distances (kilometers).

In north temperate climates, adults and nymphs have been found to overwinter on or beneath perennial host plants such as matrimony vine, bittersweet nightshade or field bindweed. This insect reproduces continuously throughout the year in sub-tropical and tropical climates.

Crop host plants

This psyllid is a pest of solanaceous plants, which include potato, eggplant, tomato, tomatillo, tobacco and ground cherry. The insect will also develop on goji berry, sweet potato and morning glories (including field bindweed). In the absence of Lso, high populations of nymphs can cause psyllid yellows, characterized by yellowing of leaves and deformed tubers in potato. The plant may recover if the psyllids are controlled before they cause extensive damage.

Lso-infected potato leaves. Credits Dan Johnson. U. Lethbridge, Canada.

The potato psyllid is native to North America; its presence has been documented via field sampling in Canada (southern and central Alberta, southern Saskatchewan and southern Manitoba), the United States (west of the Mississippi River), Mexico and Central America (Guatemala, El Salvador, Honduras and Nicaragua). The geographic range of the psyllid may be broader if greenhouse crop production is considered.

A number of methods for monitoring are used. Yellow standard sticky traps are utilized in many fields; however, visual inspection of plants for nymphs or adults is also useful, and collections without sticky traps may be conducted via powered vacuum sampling. Dislodging adults onto a tray using the beat board method can be useful when populations are of medium to high density. Sampling in weeds and some crops can be carried out using sweep nets.

Powered vacuum sampling. Credits Rodney Cooper, USDA-ARS.

Weedy hosts of potato psyllid and Lso

Weeds are sources for psyllids (Lso-infected and non-infected) that feed on solanaceous crops and may play an important role in infecting crop plants. The psyllid and bacterium develop on most weeds in the Solanaceae (nightshade) family, including *Solanum*, *Datura*, *Physalis*, *Nicotiana*, *Hyoscyamus* and *Lycium*. The potato psyllid and a related psyllid in the same genus also occur on some weeds in the Convolvulaceae (morning glory) family, including *Convolvulus*, *Ipomea* and *Calystegia*.

Bittersweet nightshade Solanum dulcamara flowers. Idaho. Credits Dan Johnson. U. Lethbridge, Canada.

Bittersweet nightshade Solanum dulcamara fruit. Idaho. Credits Dan Johnson. U. Lethbridge, Canada.

Hosts of the potato psyllid.

Management

Collaborative and coordinated management of psyllids and infected plants across regions will boost the effectiveness of control measures.

Vector control

There are several types of vector control methods, including biological, mechanical/physical, host plant resistance and chemical.

Biological control refers to the conservation and release of natural enemies and entomopathogens. With biological control, it is important to consider management practices that maintain populations of natural enemies. For example, broad spectrum insecticides will kill biological control insects, rendering this control method ineffective.

Some examples of native generalist predators that could contribute to reducing pest populations at low densities include Ladybird beetles (coccinellids), damsel bugs (nabids), lacewings (chrysopids) and minute pirate bugs (anthocorids).

Nine-spotted Lady Beetle Coccinella. Credits Dan Johnson. U. Lethbridge, Canada.

Pirate bug. Credits Dan Johnson. U. Lethbridge, Canada.

Lacewing larvae. Credits Dan Johnson. U. Lethbridge, Canada.

In Mexico and many parts of the United States, there is a specialized parasitic wasp (Tamarixia triozae, Eulophidae) that attacks and kills the psyllid. It is effective at low densities and may play an important role in controlling the insect pest on weeds, as well as in organic and conventional production.

Entomopathogenic fungi (insect disease agents) are commercially available and can be effectively utilized to control the potato psyllid if applied correctly, by targeting nymphs typically found on the underside of leaves.

Large yellow sticky bands have been effectively utilized to control psyllids in Mexico in small farming operations (See picture 17). In addition, anti-aphid screened covers are often used in seed potato production in Mexico and could be used in low acreage farming operations. Covers need to be placed before plant emergence or on insect-free plants.

Large yellow sticky bands used in Mexico to control the potato psillid. Credits Jaime Mena, Zacatecas Experimental Field, INIFAP, México.

Resistant cultivars of potato, pepper and most other crops are not currently available. However, tomato cultivars resistant to root knot nematode may confer some resistance to potato psyllid.

Integrated Pest Management (IPM) that minimizes insecticide use is the preferred method of psyllid control; however, certain insecticides are available for use. Regional regulations and recommendations should be consulted prior to utilizing insecticides. Repeated chemical usage has been demonstrated to lead to reduced efficacy due to increased insecticide resistance. Chemical resistance has already been reported in several regions. As a last resort, if chemical control is required, it is suggested to alternate the application of insecticides with different modes of action to reduce the chance of inducing resistance.

Pathogen control

To date, there are currently no cost-effective chemical, antibiotic or biological control methods for Lso; therefore, roguing or physical removal of symptomatic plants is encouraged. In potatoes, evidence indicates that symptomatic tuber seed pieces do not appear to be a source of Lso. However, symptomatic seed pieces are not recommended for planting due to lower daughter tuber yield. It is suggested that, during seasonal evaluations, plant material showing symptoms of Lso be submitted to local diagnostic labs for analysis.

Cultural control

Limiting overlapping generations of susceptible crops could potentially reduce vector populations and pathogen reservoirs in regions that do not have an overwintering period. Coordinated planting dates and crop rotation could be a beneficial cropping management strategy.

Weed control

Control of known weedy hosts in and around crop fields can help to reduce local vector populations and pathogen sources. Collaborative management of weeds across regions will further increase the effectiveness of these efforts. Weedy hosts should be removed prior to crop (potato, tomato, pepper, etc.) emergence, and be continuously managed throughout the season. In season, prior to removing the weedy hosts, it is important that psyllids are eliminated/controlled, as the pest will disperse to field crops once weedy hosts are removed.

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