

Biology and Management of Potato Psyllid in Pacific Northwest Potatoes.

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Little is known about the biology of potato psyllids in the Pacific Northwest. Even less is known about its management in potatoes grown in this region. The following article is based on information on potato psyllids from other states, limited research and observations on potato psyllids and zebra chip in the Pacific Northwest and our general knowledge of the pest, potato pest management and insecticides registered on potatoes. This document has been reviewed by more than a dozen entomologists and researchers working on potato psyllid and it is our best attempt at providing growers and potato pest management decision makers with information regarding management of this pest.

The potato psyllid is a phloem-feeding insect that has an extensive host range of at least 20 plant families, but reproducing mostly on the potato and nightshade family (Solanaceae). This insect has been very costly to cultivated solanaceous crops in the United States, Mexico, Central America, and more recently in New Zealand. In recent years, a new potato tuber disease, zebra chip (ZC), has caused millions of dollars of losses to the potato industry in the southwestern United States, particularly Texas. However, ZC was for the first time documented in Idaho and the Columbia Basin of Washington and Oregon late in the 2011 growing season. This disease is characterized by development of a dark striped pattern of necrosis in tubers (Fig 1). The pathogen associated with ZC is the bacterium *Candidatus Liberibacter solanacearum* that is vectored by potato psyllid.



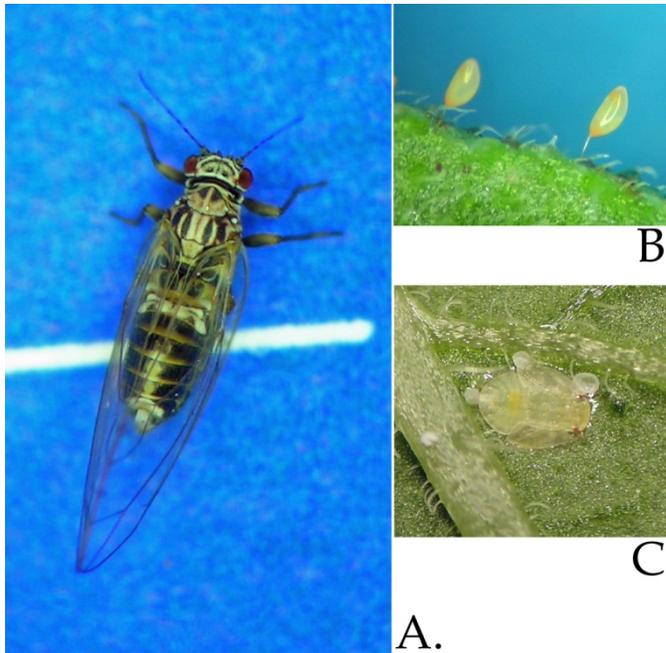
Figure 1 ZC tuber symptoms. Photo credit. S.I. Rondon, OSU.

Identification

Potato psyllids pass through three life stages: egg, nymph and adult. All life stages are difficult to detect. The adults look like small cicadas, about 0.08 inch (2 mm) long (Fig. 2A). They are closely related to aphids and leafhoppers and have clear wings that rest roof-like over the body. Although predominantly black, the potato psyllid has white markings. The first abdominal segment shows a broad white band, the last segment has an inverted white "V". Psyllids jump quite readily when disturbed.

The football-shaped eggs (Fig. 2B) are extremely small, slightly larger than leaf hairs, and on a short stalk. They are usually on the underside and along the edges of leaves and are usually laid in the upper plant canopy. A 10X hand lens is required to see them.

Psyllid nymphs (Fig. 2C) look like immature soft scale or whiteflies. Unlike whiteflies, when disturbed, they move readily. They are flat and green with a fringe of short spines around the edge. Immature psyllids go through five stages in as little as 13 days in warm temperatures.



Potato psyllid can damage a plant even if it does not carry the pathological bacterium since these insects feed directly on the plant and may weaken it. As they feed, psyllids inject toxins with their saliva that can cause leaf yellowing or purpling, smaller and fewer tubers, and misshapen tubers. This physiological condition has been dubbed “psyllid yellows” disease (Fig 3) and is generally less damaging than ZC.

Figure 2. A is adult potato psyllid, B is a psyllid egg attached to a leaf edge, C is an immature psyllid.

The insect (adult or nymph) acquires the bacterium when feeding on an infected plant. Once infected the insect is always a carrier of the bacterium. Eggs laid by an adult with the bacterium are also infected. The disease usually takes about 3 weeks from infection to produce symptoms in the foliage and tubers.



Figure 3 Psyllid yellows foliar damage. Photo credit. S.I. Rondon, OSU

First identified in northeastern Mexico in 1994 and south Texas in 2000, ZC has now been reported from California, Idaho, Kansas, Nebraska, New Mexico, Oregon, Wyoming and Washington. Also, the disease was recently reported from New Zealand. Plants affected by ZC exhibit a range of 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. The name “zebra chip” refers to the characteristic brown discoloration of the vascular ring and medullary ray tissues within the tubers that is enhanced when tubers are sliced and fried into chips or fries.

Potato psyllids will feed on and transmit the disease-causing organism to all varieties of potatoes. While there are differing susceptibilities across potato varieties, virtually all varieties will express symptoms of ZC.

The bacterium affects the phloem tissue, causing the foliar symptoms described above and higher than normal sugar concentrations in tubers. When cooked, the sugar caramelizes and forms dark brown stripes (Fig 4). The defect is harmless to consumers, although taste is different, but renders the tubers unmarketable. This disease that is not restricted to potato chips (Fig. 5). In addition, the ZC organism can significantly reduce yields and tuber size.



Figure 4. Zebra chip infected potato chips.



Figure 5. Zebra chip infected French fries.

Potato psyllid has long been known to be present throughout the Pacific Northwest. It has been thought to not overwinter in the PNW, but instead migrate into the area on air

currents from the south. There is a preliminary study by Chapman, Strube and Bextine that shows that the psyllids in the PNW are genetically related to those from California. The historical lack of ZC in PNW potatoes, even though the insect has long since been present here, is probably due to the insects in previous years not carrying the pathogen. It is possible that psyllids have carried the disease in previous years in the PNW but disease symptoms were attributed to other causes such as viral infections.

The insect is known to overwinter from California to southern Texas and northern Mexico. Research is underway to confirm whether potato psyllid overwinters in the PNW. Andy Jensen has found potato psyllid adults overwintering in the Boise, Idaho area up until the time of this writing (February, 2012). They were found in *Solanum dulcamara* L. (a.k.a. bittersweet nightshade.) This is a perennial weed native to Eurasia. It can be found in fence rows, pond margins, low woods and roadsides throughout the Pacific Northwest.

Psyllids are typically first detected in PNW potatoes in July, but the timing of the ZC outbreak in 2011 suggests that it first colonized the earliest affected fields in mid June.

Management.

Sampling. Use yellow sticky cards to detect first occurrence of population. Place yellow sticky cards such as those used for beet leafhopper in the field, near the edge. We do not have a recommended number of cards per field, but the more cards per field the more likely one will detect psyllids. Spatial and temporal studies indicated that both psyllid abundance and ZC incidence progress over time faster on the edges than in the infields early in the season. In California, 70% of the potato psyllids can be found on the field edges. 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.

A second sampling method is to collect ten leaves from ten locations from the first ten outer rows of the field. Collect full sized leaves from the middle of the plant. A hand lens is required to see psyllid eggs and nymphs. Count the number of adults and nymphs, and if you have very good eyesight, eggs. The nymphs reside on the underside of the leaf. Eggs are most commonly present on the leaf's edge. Be aware that adult potato psyllids are active and will fly or jump away when disturbed.

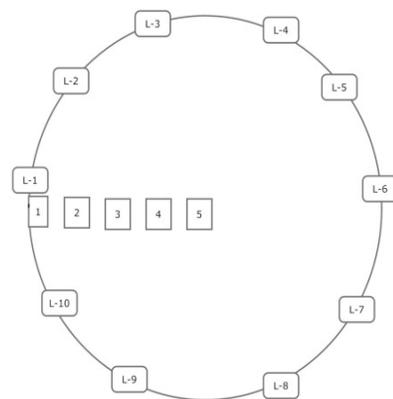


Fig. 5 Layout used in Texas (D. Henne, Texas AgriLife). Numbers 1, 2, 3, 4, and 5 represent a sticky card ; The L plus numbers, represent leaf samples.

Use of yellow sticky cards in the perimeter of potato fields is expected to be useful for early detection of psyllids. Leaf sampling is useful for monitoring eggs and nymphs. Texas A & M University recommends a mixture of using sticky cards and leaf sampling.

A third method, again originating out of Texas, is use of a sweep net. Take 100 sweeps from around the field perimeter. This method will only collect adults.

Action Threshold. No action threshold exists for psyllids in potato. We suggest that detection of potato psyllids at any level, in any life stage, is the threshold for action until we learn more about how ZC will impact PNW potatoes.

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

Chemical Control. Fortunately 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. Season long weekly applications are used in areas (e.g. Texas) where ZC has been problematic. We are not expecting 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.

Resistance Management. If a neonicotinoid (Group 4a) is applied at planting do not apply another Group 4a product later in the season. Do not apply a single mode of action more than twice in a row against potato psyllids or any other insect. For example, do not apply a pyrethroid insecticide more than twice in a row. Do not apply Agri-Mek, Monitor, Provado, Actara or any other product more than twice in a row. For example, do not apply Movento twice and then apply Oberon.

Potato psyllid has developed resistance to insecticides. For example, growers in Texas stopped using Monitor because it lost efficacy after a few years of heavy use.

In the PNW, the first 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. Also, growers may also have other insect pests to control at the same time as psyllids. Following is a table showing the spectrum of activity for insecticides that have activity against potato psyllid. The table shows activity against psyllid life stages and other pests that may be present at the time psyllids are in potato fields.

Table of Activity for Psyllid Life Stages and Other Potato Insect Pests. Each x indicates the insecticide has activity against that pest and life stage.

| | Group # | Psyllid Lifestage | | | BLH | CPB | GPA | Thrips | Worms | Mites |
|-------------|---------|-------------------|--------|--------|-----|-----|-----|--------|-------|-------|
| | | eggs | nymphs | adults | | | | | | |
| Monitor | 1b | | x | x | x | | x | x | | |
| pyrethroids | 3 | | x | x | x | x | | | x | |
| Platinum | 4a | | x | x | x | x | x | | | |
| Cruiser | 4a | | x | x | x | x | x | | | |
| Belay | 4a | | x | x | x | x | x | | | |
| Admire | 4a | | x | x | x | x | x | | | |
| Venom | 4a | | x | x | x | | x | | | |
| Radiant | 5 | | x | | | x | | x | x | |
| Agri-Mek | 6 | x | x | x | | x | | x | x | x |
| Fulfill | 9b | | x | x | | | x | | | |
| Beleaf | 9c | | x | x | | | x | | | |
| Rimon | 15 | x | x | | | x | | | x | |
| Movento | 23 | x | x | | | | x | x | | x |
| Oberon | 23 | x | x | | | | | | | x |

Growers have two kinds of strategies for controlling potato psyllids in PNW potatoes:

Option 1. Insecticide at planting time followed by foliar applications. Apply a neonicotinoid to the seed piece, in furrow at planting or at cracking, such as Admire Pro, Gaucho, CruiserMaxx, Platinum or Belay. Since potato psyllid is not present at cracking or layby, an application of these products at this growth stage is assumed to be effective. At just prior to the effective decline of the planting time insecticide, initiate a foliar insecticide program. The point at which one decides to make the first application is based on a combination of the pest management professional’s aversion to risk and the choice of product. Based on the 2011 field season, if we assumed that the potato psyllid’s first arrival to the Columbia Basin was around June 20 based on when first foliage symptoms were observed, the first foliar application should be made prior to that date. For resistance management reasons we recommend that no more than 80% of fields on a farm be treated with Group 4 neonicotinoid insecticides at planting/cracking.

Option 2. Foliar only program. At first detection of potato psyllids, start applying foliar insecticides with known effectiveness against adult potato psyllids. Continue a foliar program until psyllids are no longer present or until your field has been desiccated or harvested.

Timing of Application. Actively growing potato plants can double in size every 7 days until bloom starts. Application of contact (non-systemic) products such as pyrethroid insecticides will only provide control on the plant tissue that is present at the time of application, necessitating a shorter application interval than when using a highly systemic insecticide. Later in the season when a potato plant is not actively growing above ground, a contact insecticide will provide 14 days or longer residual control, often as long or longer than a systemic insecticide. When a potato plant is fully mature, a systemic insecticide can take up to 2-4 days to become fully translocated throughout the plant.

Method of Application. In many situations growers choose chemigation, however use of chemigation with non-systemic products may result in substantially reduced insecticide levels on the foliage. Due to our lack of knowledge on effect of method of application on efficacy, do not apply insecticides for potato psyllids in potatoes via chemigation unless you are confident the application will result in adequate deposition of insecticide residues on the foliage. Obtaining adequate coverage, particularly with contact insecticides, is critical since the immature stage of the potato psyllids prefers the underside of the leaves.

Note that much of the following information is from states from outside of the Pacific Northwest.

Planting Time Insecticide Treatments

Imidacloprid (Admire, Gaucho), thiamethoxam (Cruiser) and chlothianidin (Belay) applied at planting will provide 80 to 100 days of residual control of aphids and beetles. Outside of the Pacific Northwest, these products have provided a shorter period of residual control for psyllids. It is not known if this difference is due to the insect being more tolerant to the insecticide or due to a more rapid breakdown of the product in other regions. There are no data on how long these products will provide residual control of potato psyllids in the PNW. Based on information from other states with potato psyllid control challenges, we believe that imidacloprid, thiamethoxam and chlothianidin have similar periods of residual control for this pest. Out of an abundance of caution, we recommend that growers assume the period of residual neonicotinoid soil control for potato psyllids to be 80 days or less. Application of these three products at cracking/layby is expected to have three weeks shorter period of control. Phorate (Thimet, Phorate) is thought to not provide reliable psyllid control beyond 50 days and therefore is not expected to be of value in psyllid management. Venom is another neonicotinoid insecticide registered for use at planting time on potatoes. This product is not recommended for use in the PNW at planting for psyllid control due to its short period of soil residual control.

Admire Pro, Gaucho, Platinum, Cruiser 5FS, CruiserMaxx and Belay applied at planting time are expected to have efficacy against the potato psyllid. Length of control will vary depending on the rate used, soil and environmental conditions, and insect

pressure. It is important to note that the application rate will vary by the number of sacks planted per acre, with a maximum use rate of 0.125 lb ai/A. Do not apply any foliar neonicotinoid (Provado, Leverage, Belay, Venom, Endigo Actara, Assail) following applications of Admire Pro, Belay, Gaucho, Platinum, Cruiser 5FS and CruiserMaxx to follow resistance management guidelines established by IRAC for the insecticide group 4A.

Insecticide Seed Treatments

Belay Insecticide (clothianidin, Group 4A). Belay is a 2.13 lb/gal liquid that can be used for seed, soil or foliar treatments. Seed treatment provides control of aphid, flea beetle, Colorado potato beetle, leafhoppers, wireworms (seed piece protection) and psyllid. Apply 0.4 to 0.6 fl oz/cwt of potato seed depending on seeding rate. Maximum use rate is 0.2 lb ai/A of clothianidin (Belay). Mix 1 part Belay with 3 parts water. Inert dusts or dust-based fungicides can be applied after Belay application to potato seed pieces.

Tops MZ Gaucho (imidacloprid, Group 4A). These seed treatments control aphid, Colorado potato beetle, flea beetle, potato leafhopper, and psyllids in a dust formulation. Application rate is 0.75 lbs/cwt., or 20lbs/acre maximum. Do not apply any foliar product that contains neonicotinoid (Provado, Leverage, Actara, Assail, Belay, Endigo, Venom) following this application.

Admire Pro (imidacloprid, Group 4A). Admire Pro is a liquid seed piece treatment offering control of all aphid species, Colorado potato beetle, flea beetle, potato leafhopper, and psyllids with the flexibility of ultra-low volume liquid seed-piece application. Admire Pro may also reduce wireworm damage in seed-pieces. The application rate is 0.17 – 0.35 fl. oz./cwt. of seed-pieces (Note: Based on a 2000 lb/acre seeding rate, this rate range is equivalent to 3.5 -7.0 fl. oz./acre). Do not apply any foliar neonicotinoid (Provado, Leverage, Venom, Endigo Actara, Assail) following this application.

Cruiser 5FS/CruiserMaxx Potato (thiamethoxam, Group 4A). Cruiser is a seed-applied neonicotinoid product recently registered for use on potatoes. Use CruiserMaxx Potato seed treatment to provide protection against injury from aphids, Colorado potato beetles, flea beetles, and psyllids. Cruiser 5FS will also control wireworms that feed on the seed piece. The rate range is 0.19 to 0.27 oz per 100 lbs of tubers, depending on the seeding rate (consult label). Length of control will vary depending on the rate used, soil and environmental conditions, and insect pressure. Use approved application equipment (Spudgun or Milestone barrel treater). It is important to note that the application rate will vary by the number of sacks planted per acre with a maximum use rate of 0.125 lb ai/A. This Cruiser Maxx Potato formulation is a combination of Cruiser 5FS, Maxim 4FS and a drying agent. The drying agent dries the seed more quickly

aiding in suberization. Do not apply any foliar neonicotinoid (Provado, Leverage, Venom, Endigo Actara, Assail) following this application.

Insecticide In-Furrow Treatments

Platinum 75SG (thiamethoxam, Group 4A). Platinum is a soil-applied insecticide providing long residual control in potatoes. Apply Platinum 75SG at 1.67 to 2.67 oz/A in-furrow at planting in a 6-8 inch band with sufficient water for good coverage for the control of aphids, Colorado potato beetle, potato leafhoppers, flea beetles, and potato psyllid. Do not apply less than 1.67 or more than 2.67 oz/season. Do not apply if any neonicotinoid (Group 4A: CruiserMaxx, Belay or Admire Pro) has been applied as a seed treatment. Alternatively, Platinum may be applied POST plant, pre-emergence as a broadcast application at 1.67-2.67 ounces/acre and watered in with 0.10 -0.25 inches of water. All precautions listed above must be followed.

Admire Pro (imidacloprid, Group 4A). Admire Pro is a soil-applied insecticide providing long residual control of insect pests of potatoes, including psyllids. Admire Pro will control Colorado potato beetles, aphids, wireworms (seed piece only), and psyllids. Dosage rates are 5.7 to 8.7 fl oz/A applied as an in-furrow spray at seeding or as a side dress to both sides of the hill after planting (treated areas of both hillsides should be covered with approximately 3 inches of soil).

Belay Insecticide (2.13 SC) (clothianidin, Group 4A). Belay is the least water soluble neonicotinoid with a comfortable Koc value (160 mg/gm), which ensure that the product does not leach and/or gets bound with soil colloids in a wide range of soil types in the potato production areas. Thus, Belay is a highly systemic product that is readily available for uptake and has activity against insect with chewing and sucking mouthparts. Apply Belay at 9-12 fl oz/A in-furrow at planting, or at soil cracking for psyllid, Colorado potato beetle, aphids, flea beetle, leaf hoppers, wireworm (seed-piece protection) and white grub control. Use between 5-10 gallons of water per acre. Belay has an REI of 12 hours. Water in immediately after application when applied at soil cracking. Belay has no crop rotation restrictions.

Foliar Insecticide Psyllid Treatments

Do Not Use These Products for Psyllid Control. Lannate, dimethoate, Sevin, Imidan, Regent, Mocap, Avaunt, Comite, Acramite, Coragen, Success and malathion. These products have very short residual or no efficacy against potato psyllids; other options exist that have better efficacy and/or longer periods of control.

Pyrethroid Insecticides (Group 3): Asana, Battalion Brigadier, Hero, Baythroid, Ambush, Brigade, Mustang Max, Warrior II and Permethrin. These products have activity against potato psyllids. Additionally, these products will control several other

insect pests such as Colorado potato beetle and beet leafhopper. Use of these products is discouraged in most potato pest management scenarios due to their potential to cause aphid and mite outbreaks. *Potato psyllids are closely related to aphids and share several characteristics with them. Experiences in controlling psyllids in Texas potato fields found that over reliance on pyrethroid insecticides tended to flare potato psyllid populations thereby creating unacceptable losses.* In some situations, these products may be appropriate for control of potato psyllids in potatoes. ***We strongly recommend against use*** of pyrethroid insecticides between June 15th and two weeks before desiccation. If pyrethroid insecticides are applied prior to June 15th, applications should be made every seven days if plants are actively growing. If a field is within 14 days of harvest or desiccation, a pyrethroid insecticide can be an effective tool and would also serve as an important resistance management tool. Many pyrethroid insecticides have short preharvest intervals making them suitable end of season choices. Most package mixes contain a pyrethroid insecticide. Statements made for products containing pyrethroid insecticides also apply for package mixes that contain a pyrethroid insecticide. A study from Texas showed that psyllids exposed to pyrethroids produced 30% more eggs before they died from the insecticides than did psyllids not exposed to insecticides.

Provado/Admire Pro, Actara, Belay and Venom (Group 4a). Due to lack of efficacy data, neonicotinoid insecticides are not recommended for foliar control of potato psyllids.

Vydate (oxamyl, Group 1B). Efficacy of Vydate against potato psyllids is unknown. . Anecdotal information from Oregon and Washington in 2011 suggest that Vydate applied to fields containing potato psyllids did not provide control, however, these fields may have already been infected before Vydate applications began." Neither we nor DuPont recommend the use of Vydate for psyllid control.

Fulfill (pymetrozine Group 9B). Apply Fulfill at the full label rate of 5.5 ounces per acre using a penetrating surfactant. Use the higher rate when treating psyllid populations. This product should be applied just prior to the "break" in control of soil applied insecticide or at the very first detection of potato psyllids in the field. A minimum of five gallons of water should be used when applying Fulfill by air. Fulfill can be applied via irrigation systems. The Fulfill label permits a maximum of only two applications. When applying Fulfill by ground or air use an oil blend adjuvant. Always use a penetrating adjuvant when used with other products that contain sticker/binder-type adjuvants (e.g. Bravo Weather Stik, Bravo Ultrex or DithaneRainshield. Examples of appropriate adjuvants include crop oil concentrates (COC) (e.g. Herbimax), methylated seed oils (MSO) (e.g. Dynamic), ethylated seed oils (ESO) (e.g. Hasten) and organosilicone (OS) blends (e.g. Aerodynamic). Note, there is no quick knock down of psyllid populations with Fulfill; the product causes psyllids to cease feeding, with actual death occurring in 3-5 days.

Beleaf (flonicamid Group 9C). Apply Beleaf at 2.0 to 2.8 ounces per acre. The product may be applied by ground, air or chemigation for aphid control. This product will only control aphids and potato psyllids. Apply no more than 3 applications per season. Beleaf has a 7 day pre harvest interval.

Radiant SC (spinetoram, Group 5). Apply 6 to 8 fluid ounces of Radiant per acre by air, ground or chemigation. Time applications to target egg hatch or young nymph. For heavy larval populations, repeat applications may be necessary but follow resistance management guidelines. Applications by chemigation at either rate should be made with 0.25 acre inches of water or less. Acidic (< 6 pH) spray solutions should be avoided. The pH of spray solution should be checked prior to adding Radiant into the tank and adjusted, if necessary. Acidifying products such as boron should be avoided. In addition, prior to adding Radiant to a tank it is recommended to conduct a compatibility test.

Agri-Mek/Agri-Mek SC (abamectin, Group 6). Apply 8 to 16 ounces of Agri-Mek 0.15 EC or 1.75 to 3.5 fl oz of Agri-Mek SC by air with 5 gallons of water per acre. Avoid using Agri-Mek with any product containing sticker/binder-type adjuvants (e.g. Bravo Weather Stik, Bravo Ultrex or DithaneRainshield). The addition of a nonionic surfactant or organosilicone-based surfactant, at the manufacturer's recommended rate is suggested for optimum control. Agri-Mek has activity against adult psyllids.

Rimon 0.83 EC (novaluron, Group 15). Rimon may be applied by air, chemigation or ground equipment at 9 to 12 fl oz/A. Applications should be made before psyllid populations reach adulthood. Rimon is an insect growth regulator type insecticide which must be ingested by nymphs or applied either over or under eggs to act as an ovicide; therefore, reapplication at 7 to 14 days is needed to protect new plant tissue during periods of active foliar growth. It will not control adult psyllids. Do not make more than two applications per season. Do not apply to two successive generations in the same growing season. Use a minimum of 5 gallons per acre when applying by air; apply a minimum of 10 gallons per acre when applying by ground. Rimon has a 12 hour restricted entry interval and a 14 day pre harvest interval. Do not apply more than 24 ounces per acre per season.

Monitor (methamidophos Group 1B). The registrant has removed Monitor from the market place and it is no longer commercially available to purchase. Existing stocks may be used as long as product is available. Monitor has a discernable shelf life. Growers should not store Monitor for longer than two years without expecting the potential for reduction in efficacy. Apply Monitor at the full label rate of 2 pints of product just prior to the "break" in control of the soil applied insecticide or as soon as potato psyllids are detected. Applications of insecticides should continue until susceptibility to ZC has passed. Monitor should be applied according to the following intervals: 14-day intervals when canopy is open, 10-day intervals when canopy is completely closed over and 7-day intervals when canopy becomes compacted. The

Monitor label permits a maximum of four applications. A minimum of five gallons of water should be used when applying Monitor by air. Do not apply Monitor via an irrigation system. [Application of Monitor through an irrigation system may be an appropriate choice for locations where aerial or ground applications are prohibited, such as portions of the Tri-Cities area in Washington.]

Oberon 4SC (spiromesifen Group 23). May be applied by air, ground, or chemigation for control of psyllids. Good coverage of the foliage is necessary for optimal control. An adjuvant may be used to improve coverage and control. For best results the treatment should be made at first occurrence of psyllids and before a damaging population becomes established. Oberon is most effective against the egg and nymphal stages of psyllids. Control should be directed at these stages. Oberon can be applied at 4 to 8 fluid ounces per acre. Apply when psyllids first appear and prior to leaf damage or discoloration. Apply in adequate water for uniform coverage with ground or aerial application equipment, or by chemigation as per the use label. If needed, repeat an application of Oberon at a 7- to 10-day interval. There is a limit of two applications per season. Applications of Oberon at the 4 oz rate are not recommended by air or chemigation except for situations where psyllid pressure is low or when applied sequentially as a split application following higher rates of Oberon as needed. Based on observations of field applications, applications via chemigation have been more effective than by air

Movento (spirotetramat, Group 23). Movento may be applied by air, ground or chemigation for control of psyllids. The manufacturer of Movento recommends air or ground application of the product when treating for psyllids. Apply Movento at 5.0 ounces of product per acre. Movento requires up to 14 days to become fully effective in the plant. If following an application of a neonicotinoid at planting/cracking, apply Movento at 10 days prior to expected "break" of the planting time insecticide. Research has shown that the most effective means of controlling psyllids, aphids and other pests is to apply the product twice with a 10 to 14 day retreatment interval. For resistance management purposes, do not allow more than 21 days between applications of Movento unless an insecticide with a different mode of action is applied between the two applications. If a planting time insecticide has not been made, apply Movento at the first appearance of potato psyllid. The product is more effective when applied earlier in the outbreak cycle due to its systemic properties and efficacy against eggs and nymphs. Use of Movento requires inclusion of a penetrating surfactant, the manufacturer of Movento recommend use of an MSO. One use feature for this product is that there is a 30 day plant back restriction after the last application for all crops. Since this product would almost always be applied more than 30 days before harvest, there are functionally no plant back restrictions for Movento.

Storage

- Little information is available on the biology of the disease in storage; however, there is research that shows asymptomatic tubers produced by potato plants infected late in the season may later develop ZC symptoms in storage.
- Experience with this disease in other locations suggest that infected tubers do not rot in storage.
- Tubers with symptoms put into storage will maintain those symptoms.