

Potato Psyllid and Zebra Chip (ZC)

Alan Schreiber, Agriculture Development Group, Inc., Andy Jensen, Regional Research Director, for the Idaho, Oregon and Washington Potato Commissions and Silvia Rondon, Oregon State University.

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 (ZC) 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 24. Zebra chip tuber symptoms.
Photo S. Rondon, OSU

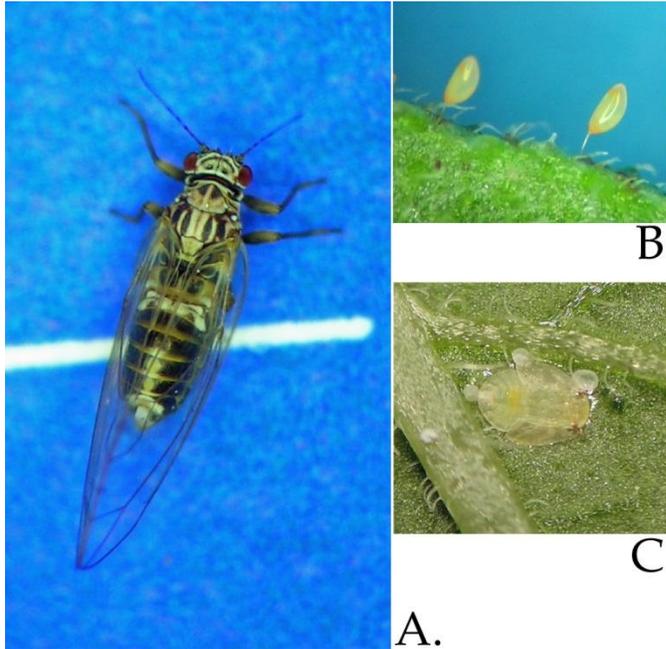


IDENTIFICATION .

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 25. A is adult potato psyllid, B psyllid eggs attached to a leaf edge, C is

an immature psyllid.

The psyllid acquires the bacterium when feeding on an infected plant or from its mother who can transmit the bacterium to her offspring via the egg. Once infected the insect is always a carrier of the bacterium. The disease usually takes about 3 weeks from infection to produce symptoms in the foliage and tubers.



Figure 26. 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 tested so far. 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 27). Though not a human health concern, ZC negatively affects the taste of fried products and renders the tubers unmarketable. This disease is not restricted to potato chips (Fig. 28). In addition to causing tuber necrosis, the ZC organism can significantly reduce yields and tuber size.



Figures 27 and 28. Zebra chip infected French fries and zebra chip affected potato chips.

Psyllid and ZC Biology

Potato psyllid has infested potato fields in the Pacific Northwest for decades but was never considered a pest until the advent of ZC in the region. It is thought to migrate from other regions of the country, but this has not been demonstrated. Research during 2011 and 2012 has proven overwintering of this psyllid in both Oregon and Idaho in association with the perennial weed called bittersweet nightshade (*Solanum dulcamara*), a perennial weed native to Eurasia. It can be found in fence rows, stream banks, pond margins, low woods and roadsides throughout the Pacific Northwest. The relative significance of this overwintering life style versus long-range migration is still uncertain.

The potato psyllid is now known to have at least three genetically distinct biotypes in North America, with evidence emerging about variability amongst them in terms of mating and ecology. The importance of these biotypes and whether one or all are relevant to ZC are not yet known.

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.

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. Theoretically, the only important psyllids are those that carry the ZC pathogen, *Liberibacter*. It is generally possible to detect *Liberibacter* in psyllids using PCR tests. Recently, however, research has shown that some psyllids that initially test negative for *Liberibacter* may actually carry it in very low concentration. Therefore, much research is underway to determine 1.) the extent to which psyllids can carry extremely low numbers of *Liberibacter* cells, 2.) whether such carriers are important in the field, and 3.) whether new testing methods can be developed to reliably detect extremely low *Liberibacter* levels in psyllids. An additional complicating factor in ZC biology is that there are at least 2 biologically distinct, genetically different, biotypes of the *Liberibacter* that infects potatoes. Initial research information suggests that one biotype causes a more severe foliar disease than the other. It is not known how important this is in the real world of crop production, or whether the diverse psyllid/*Liberibacter* biotype interactions are relevant to growers and IPM.

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								
		eggs	nymphs	adults	BLH	CPB	GPA	Thrips	Worms	Mites
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 Pro	4a		x	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

When the PNW potato psyllid recommendations were written in 2012 no data existed in product efficacy. During 2012 extensive efficacy trials were conducted in 2012 generating data for a large number of products however the data was generated under relatively low pressure situations and with psyllid that had very low levels of infectivity by Liberibacter. The guidelines contained herein should be viewed with the caution that products may perform better in a low pressure situation than they would in a higher pressure situation.

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, or Platinum. 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 2012 field research season, Neonicotinoid insecticides appeared to provide at least 80 to 90 days of residual control. A foliar program should begin no later than 80 to 90 days after application of a neonicotinoid program. 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.

Foliar only program. If no planting time insecticides are applied then start a foliar insecticide program at the first detection of potato psyllids in your area (do not wait until psyllids are detected in a particular field). Apply foliar insecticides with known effectiveness against adult potato psyllids at the beginning of your program. Continue a foliar program 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 psyllid prefers the underside of the leaves.

Planting Time Insecticide Treatments

Imidacloprid (Admire Pro, 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. Based on information from other states with potato psyllid control challenges, we believe that imidacloprid and thiamethoxam 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 to 90 days. Application of these 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. It is expected that Benevia, a new product is expected to be registered in 2013, but its use is not recommended for planting time control of potato psyllids.

Admire Pro, Gaucho, Platinum, Cruiser 5FS, and CruiserMaxx 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. For seed piece treatments, it is important to note that the application rate will vary by the number of sacks of treated seed planted per acre. 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 lbai/A. Do not apply any foliar neonicotinoid (Admire Pro, 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

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 (Admire Pro, 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 (Admire Pro, 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 lbai/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 (Admire Pro, 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. Do not apply any foliar neonicotinoid (Admire Pro, Leverage, Venom, Endigo Actara, Assail) following this application.

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).

Foliar Insecticide Psyllid Treatments

Do Not Use These Products for Psyllid Control. Lannate, dimethoate, Sevin, Regent, Mocap, Avaunt, Comite, Acramite, Coragen 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.

Method of Application. All successful efficacy data collected for potato psyllid in the Pacific Northwest was generated by ground applications. Efforts to collect efficacy data by chemigation was not successful in 2012. Due to lack of data showing that psyllid control is possible with use of chemigation, we are not recommending use of chemigation for control of potato psyllids.

Pyrethroid Insecticides (Group 3): Asana, Athena, 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.

Transform WG (sulfoxaflor, 4C). Apply for control of potato psyllid by ground, air or chemigation at 2.0 to 2.25 ounces per acre. Refer to the label for specific instructions when applying via chemigation. Transform has a 7 day preharvest interval, a 14 day retreatment interval and a total seasonal limit of 4 applications and a total of 8.5 ounces of Transform per acre per year. Transform can be used during the season if a neonicotinoid (Group 4A)

insecticide has been applied at planting as long as an insecticide with a different mode of action has been applied to the target pest prior to the use of Transform

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 Dithane Rainshield). 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. Always use a high quality organosilicone blend surfactant with Beleaf

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.

Blackhawk (spinosad, Group 5). Apply 3.5 oz ounces of Blackhawk per acre to potatoes for control of potato psyllid by ground. Begin at first signs of infestations. Due to the occurrence of multiple generations in a growing season, repeated applications may be required. Under moderate to high pest pressure, do not extend application interval beyond 7 to 10 days. Follow resistance management recommendations on the product label.

Entrust 2SC (spinosad, Group 5). Apply at 6 to 10 ounces per acre by air, ground or chemigation. Do not apply more than 2 Group 5 product per acre per acre consecutively (Success, Blackhawk, Entrust, Radiant) in a season. The application interval and the preharvest interval are both 7 days. There is a seasonal limit of 4 applications and 21 ounces of products than can be applied.

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

Ultrix 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.

Knack (pyriproxyfen, Group 7c). Apply Knack by ground at 8 fluid ounces at 20 to 40 gallons of water. Knack is an insect growth regulator and has no activity against adults. Its primary activity is against immature stages and may have some activity against eggs. Potatoes do not appear on the Section 3 label but it is registered for use in Washington via supplemental labeling. Knack has a 3 day preharvest interval and a 14 day interval between applications and seasonal limit of two applications and 16 ounces total. Knack has a 30 day plant back restrictions for several crops.

Rimon 0.83 EC (novaluron, Group 15). Rimon may be applied by air, chemigation or ground equipment at 9 to 12 floz/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.

Onager (hexythiazox, Group 10) is effective against eggs and immature psyllids. It may be applied by air or by ground at 16 to 24 ounces per acre. When applying by air, use a minimum of 5 gallons of water. The product may only be used in Idaho, Oregon and Washington. Do not apply within 21 days of harvest. It is critical to use Onager prior to adult psyllid buildup as the product will not control adults. Use higher rates for larger plants with a dense canopy. Do not plant rotational crops other than those on the Section 3 label within 120 days of this application.

Oberon 4SC (spiromesifen Group 23). May be applied by air, ground, or chemigation for control of psyllids. Application of Oberon by chemigation is not recommended due to lack of data demonstrating efficacy. 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.

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 the two applications of Movento and always rotate to an insecticide with a different mode of action following the two Movento 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.

Vydate, (oxamyl, Group 1b). Research conducted in Oregon in 2012 indicated that an insect program that included Vydate at planting at 4.2 pints infurrow followed by Vydate applied bi-weekly at 800 degree days for seven foliar applications at 2.1 pints per acre applied via chemigation significantly reduced expression of zebra chip. DuPont has releases a 2ee label describing this use pattern which is effective for Washington, Oregon and Idaho.

Organic Control of Potato Psyllid.

Research conducted in 2013 demonstrated that organic products provided significant control of potato psyllid. While there are no organic at planting time controls of psyllids, foliar products did provide control comparable to that of conventional products. Apply products at first detection, apply products at higher rates, at seven day intervals and to improve efficacy, apply products as tank mixes. Although there is limited data to support, addition of sulfur to psyllid treatments appeared to improve efficacy.

Entrust 2SC (spinosad, Group 5). Apply at 6 to 10 ounces per acre by air, ground or chemigation. Do not apply more than 2 Group 5 product per acre consecutively (Success, Blackhawk, Entrust, Radiant) in a season. The application interval and the preharvest interval are both 7 days. There is a seasonal limit of 4 applications and 21 ounces of products than can be applied.

Aza-Direct (azadiractin, Group # Unknown). Apply at a rate of 3.5 pints per acre by air, ground or chemigation. When applying Aza-Direct via chemigation refer to the label for significant other instructions as application of this product through water requires a set of conditions that are critical for successful outcome. For example forbids application of Aza-Direct via chemigation if the pH of water exceeds 7 which commonly occurs with surface water used for irrigation.

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.