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Matrimony Vine: Friend or Foe in the Battle Against Potato Psyllid?

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Populations of potato psyllid, the vector of the pathogen that causes zebra chip disease (Figure 1), can fluctuate substantially from year to year in the Pacific Northwest. Annual psyllid trap catches across the region can range from just a few hundred psyllids to tens of thousands (Figure 2). Until recently, the risk of large potato psyllid populations has been challenging to predict in any given year. The difficulty in forecasting the risk of regional potato psyllid infestations has been due to a lack of information about the non-crop sources of potato psyllids that colonize potato. Our research has focused in part on identifying the non-crop host plants of potato psyllids and the zebra chip pathogen. We have found that one perennial species, called matrimony vine or *Lycium,* appears to be particularly important for potato psyllids in early spring. Fortunately, this plant is not susceptible to the zebra chip pathogen and therefore does not appear to be a source of *infected* psyllids that colonize potato. However, populations that occur in matrimony vine in early spring are highly correlated with those that occur in potato in late August. This correlation is allowing us to predict as early as March whether potato psyllid populations will be extremely high as seen in 2016, or relatively low as seen in 2017 (Figure 2).

Figure 1. Zebra chip of potato is caused by a bacterial plant pathogen called Liberibacter that is transmitted by potato psyllid (Left). Disease symptoms include plant death and production of striped patterns in tubers (Right) that become exacerbated upon frying.

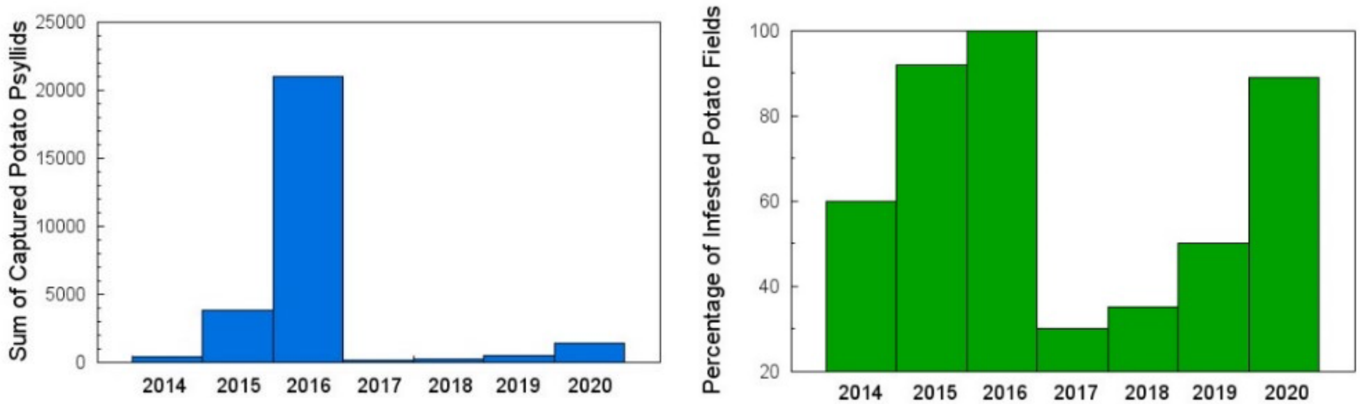

Figure 2. (Left) The number of potato psyllid captured can vary from year to year between a few hundred to tens of thousands, and (Right) percentage of potato fields that become infested with potato psyllid can range annually from less that 30% to 100%.

Matrimony Vine: The Psyllid Forecaster

Matrimony vine is native to Europe and Asia and arrived in the Pacific Northwest by two very different human assisted routes (Horton et al. 2016). One source of matrimony vine was the Euro-American settlers and homesteaders who planted matrimony vine as they moved into the western United States in the 1800s and early 1900s. This shrub was considered a “pass-along” plant that was gifted to newly wedded couples, a practice that helped spread matrimony vine between homesteads. The other source of this shrub was the Chinese immigrants that arrived in the western United States in the mid-1800s and found work in the railroad industry. Matrimony vine, or goji berry as it was known to the Chinese immigrants, was widely planted as food and medicine in camps and towns where the Chinese workers settled. Matrimony vine is well-adapted to survive the semi-arid climates of the inland Pacific Northwest, and is still commonly found today near abandoned homesteads, homestead cemeteries, and railroad camps.

Matrimony vine survives dry summer conditions by entering a state of dormancy that leads to partial or complete defoliation (Figure 3). This dormancy is triggered by several weeks without precipitation, which corresponds with June in the Columbia Basin of Washington (Thinakaran et al. 2017, Cooper et al. 2019a). The dormancy is broken when precipitation returns in autumn, leading to the growth of new leaves, flowers, and fruit. Thus, matrimony vine phenology is characterized by two periods of leaf flush in the spring and in autumn, separated by periods of dormancy in summer and winter. Sampling matrimony vine for potato psyllids has revealed that psyllids are present on matrimony vine during periods of leaf flush in spring and autumn and are largely absent from matrimony vine during the periods of dormancy in winter and summer. We believe that defoliation of matrimony vine in June forces potato psyllids to disperse and locate new hosts, which likely includes potato (Cooper et al. 2019a). This idea is supported by observations showing that the

Figure 3. Matrimony vine stand near Richland, WA in a state of spring leaf flush in May 2019 (Left) and in state of summer dormancy in August of 2019 (Right).

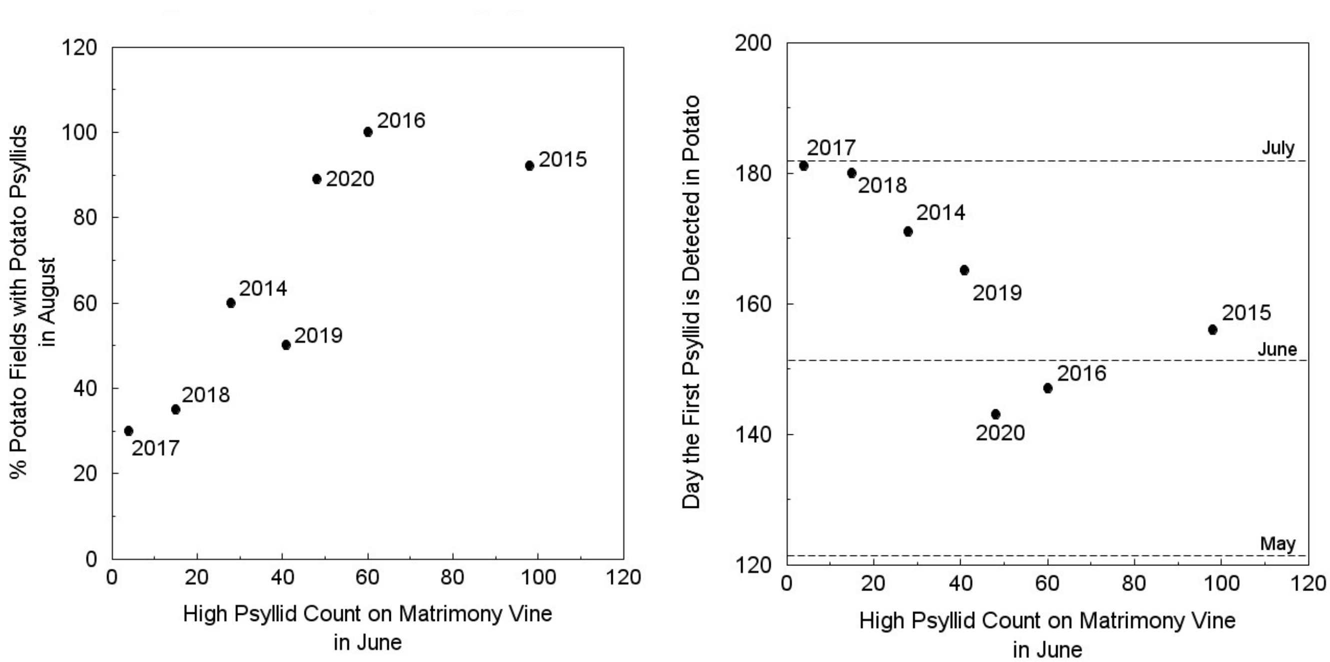

Figure 4. The number of potato psyllids captured from matrimony vine in June correlated very well with the percentage of potato fields that become infested in August (Left) and with the date when psyllids first arrive in potato (Right).

initial appearance of psyllid in potato fields occurs at the very same time that psyllids begin disappearing from matrimony vine (Horton et al. 2016, Thinakaran et al. 2017).

We have found that psyllid density on matrimony vine in June is highly correlated with the percentage of potato fields showing psyllid infestations the following August and with the date on which psyllids are first captured in potato fields (Figure 4) (Cooper et al. 2019b). Although psyllid populations are very low on matrimony vine in March, we are finding that those numbers also correlate with psyllid densities in potato fields during summer. In fact, the mere detection of psyllids on matrimony vine in March appears to be associated with large regional psyllid outbreaks in summer (Figure 5). These correlations are allowing us to forecast as early as March whether growers will see a high or low risk of summer potato psyllid infestations. These psyllid forecasts could help growers make informed psyllid management decisions at planting, and help researchers ensure that resources, including personnel, are available for summer potato psyllid monitoring and testing.

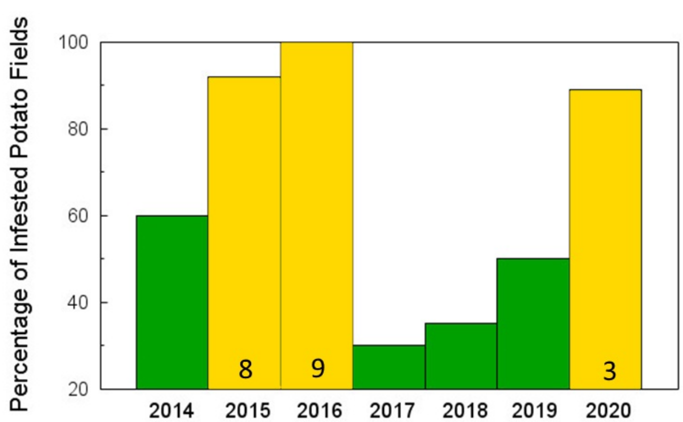

Figure 5. The presence of potato psyllids on matrimony in March was associated with large regional summer populations occurring in 2015, 2016, and 2020 (yellow bars). The number of psyllids collected from matrimony vine in March are provided for those three years. Psyllids were not detected on matrimony vine in years marked with green bars. We collected up to 31 psyllids from matrimony vine March of 2021, suggesting that we may expect larger than normal populations of potato psyllid to occur in the Columbia Basin during summer of 2021.

Matrimony Vine and the Zebra Chip Pathogen

Although matrimony vine is a good host for potato psyllid, thus far we have no evidence that matrimony vine is susceptible to the zebra chip pathogen (Cooper et al. 2019c). We have tested foliage from dozens of stands of matrimony vine located in Washington, Oregon, and Idaho and never detected the zebra chip pathogen. Furthermore, the zebra chip pathogen has not been detected from any of the >2,000 psyllids collected from stands of matrimony vine in the region. Laboratory studies support these field observations. Attempts to inoculate matrimony vine with the zebra chip pathogen have not been successful and infected potato psyllid colonies that are reared on matrimony vine mostly lose the pathogen after just one generation (Figure 6).

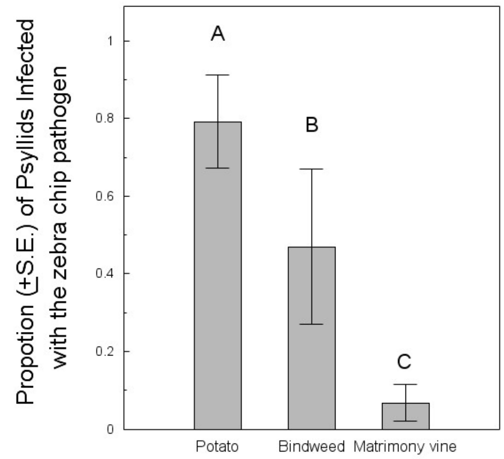

Figure 6. The proportion of potato psyllids infected with the zebra chip pathogen after being reared on potato, field bindweed, or matrimony vine for 1 generation.

Native *Lycium* Species of the Desert Southwest

Several dozen species of *Lycium* that are related to matrimony vine occur in the southwestern United States (Horton et al. 2016). Like matrimony vine, these shrubs survive the dry conditions of summer by entering a period of dormancy marked by defoliation. Researchers in the mid-1900s recognized these native shrubs as sources of potato psyllid infestations occurring in potato. Recently, molecular gut content analysis revealed that many potato psyllids arriving in potato fields in the Rio Grande Valley of Texas did so from native *Lycium* species that occur in that region. It thus appears that native *Lycium* species of the southwest have a very similar role in potato psyllid dispersal and infestation in potato as does matrimony vine in the Pacific Northwest.

Figure 7. Lycium carolinianum is native the Rio Grande Valley of Texas. The plant on the left is healthy, whereas the plant on the right has been inoculated with psyllids carrying the zebra chip pathogen. PCR confirmed that the leaves of the plant on the right were infected with the zebra chip pathogen.

We obtained seed of native *Lycium* species from USDA-GRIN and found that potato psyllid can develop on all of the native species that we tested in the greenhouse. We also found that at least some of these species are susceptible to the zebra chip pathogen, including two species that occur in the Rio Grande Valley of Texas (Figure 7). Zebra chip disease is a bigger problem for growers in the Rio Grande Valley than it is for growers in the Columbia Basin of Washington, perhaps because the species of *Lycium* that occur in that region also serve as reservoirs of the zebra chip pathogen, unlike the *Lycium* species in Washington.

Which other weeds are important?

Our research suggests that the specific weed sources of potato psyllids that colonize potato very likely vary regionally, and whether zebra chip disease is a consistent problem in a potato growing region likely depends upon which weedy hosts are available to psyllids before potatoes emerge. Unfortunately, we still do not know the cause of the 2011/2012 outbreaks of zebra chip disease that occurred in the Pacific Northwest, or the causes for isolated zebra chip outbreaks that have occurred in the region since. But we believe that a major contributing factor for zebra chip outbreaks is the availability and use by psyllids of weedy hosts that serve as reservoirs for the zebra chip pathogen. Two weedy hosts that are a focus of continuing research in the Pacific Northwest include field bindweed and longleaf groundcherry (Figure 8).

We previously considered field bindweed to be a low risk for infected potato psyllids because 1) we have thus far failed to show that field bindweed is susceptible to the zebra chip pathogen, and 2) this plant is

Figure 8. Field bindweed (Left) and longleaf groundcherry (Right).

a poor and unpreferred host of potato psyllid (Cooper et al. 2019c, b). A related psyllid called bindweed psyllid occurs in large numbers on field bindweed. Up to 30% of bindweed psyllids collected from wild stands of bindweed carry the zebra chip pathogen in Washington and western Idaho (Borges et al. 2017). We do not consider bindweed psyllids to be a direct threat to potato because they do not feed on the phloem of potato and do not transmit the pathogen to potato (Borges et al. 2017, Mustafa et al. 2021). They do however transmit the pathogen to species of Convolvulaceae that are known to be susceptible to the zebra chip pathogen (Cooper, unpublished).

Despite the lack of evidence that field bindweed is susceptible to the zebra chip pathogen, the pathogen can be transmitted from infected to uninfected psyllids if they occur on the plant *at the same time*; a process we call "plant-mediated transmission" (Torres et al. 2015, Borges et al. 2017). Potato psyllids occasionally occur on bindweed in autumn and are often collected from bindweed along with bindweed psyllids (Wenninger et al. 2019). In 2019 and 2020, we collected five potato psyllids from bindweed located near Wapato, WA in late autumn, and three of those potato psyllids were infected with the zebra chip pathogen. Although numbers of potato psyllid were low on this plant, the high rate of pathogen infection is concerning.

Longleaf groundcherry is a very good host of potato psyllid and is also susceptible to the zebra chip pathogen (Reyes Corral et al. 2020). It is available later in the year than matrimony vine but still emerges before potato. The zebra chip pathogen is capable of overwintering in underground rhizomes of longleaf ground cherry, which then produce infected plants the following spring from which psyllids can acquire the pathogen before the emergence of potato. Groundcherry is not widespread in the Columbia Basin of Washington and Oregon but occurs with frequency in the potato growing regions of western Idaho and eastern Oregon. There is potential for groundcherry to spread and become more abundant in the Columbia basin if landscape or climatic conditions become more favorable for this plant.

Matrimony Vine: Friend or Foe?

The widespread presence of matrimony vine in the Pacific Northwest may be the reason why zebra chip disease is not as important of a problem for growers in this region as it is in other regions where non-crop hosts of the pathogen are more prevalent. It is one of the first – perhaps the first – host plant of potato psyllid to become available in early spring and may prevent potato psyllid populations from building up on less preferred hosts that are possible reservoirs for the zebra chip pathogen. Potato psyllids complete at least one full generation on matrimony vine in early spring before dispersing to potato, and psyllids may lose the zebra chip pathogen during that time. Large populations of potato psyllid cause 'psyllid yellows' in the absence of the zebra chip pathogen, as was seen during the 2016 outbreak. Yet our ability to forecast the risk of potato psyllid outbreaks in the region based on population densities occurring on matrimony vine in spring will help growers take appropriate actions during years when outbreaks are expected. Our team will continue to monitor psyllid populations in matrimony vine to provide growers with psyllid risk forecasts. With funding from the USDA-ARS/State Partnership program, we will be using predator gut content analysis to identify key predators of potato psyllid on non-crop hosts including matrimony vine. An aim of this study is to determine whether high rates of parasitism on non-crop hosts in early spring correlate with low regional psyllid population densities during summer. We are also exploring reasons other than biological control, such as winter severity, for the large year-to-year size differences in potato psyllid populations. Finally, we will also continue to monitor psyllids on other non-crop host plants, especially bindweed, so that we may one day forecast the risk of a zebra chip outbreak.

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