Virus Research xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Virus Research

journal homepage: www.elsevier.com/locate/virusres

Agroecological and environmental factors influence Barley yellow dwarf viruses in grasslands in the US Pacific Northwest

Laura L. Ingwell[a,b,*], Christelle Lacroix[c,d], Paul R. Rhoades[a], Alexander V. Karasev[a], Nilsa A. Bosque-Pérez[a]

[a] University of Idaho, Department of Plant, Soil and Entomological Sciences, Moscow, ID 83844-2339, USA
[b] Purdue University, Department of Entomology, West Lafayette, IN 47907, USA
[c] Department of Ecology, Evolution, and Behavior, University of Minnesota, Saint Paul, MN 55108, USA
[d] INRA, UR0407 Plant Pathology, F-84143 Montfavet, France

ARTICLE INFO

Keywords:
Conservation reserve program
Palouse Prairie
Luteoviridae
Virus ecology
Virus grass hosts
Virus epidemiology

ABSTRACT

Plant pathogens can play a role in the competitive interactions between plant species and have been understudied in native prairies, which are declining globally, and in Conservation Reserve Program (CRP) lands in the United States. *Barley/Cereal yellow dwarf virus* (B/CYDV) are among the most economically important disease-causing agents of small grain cereal crops, such as wheat, and are known to infect over 150 *Poaceae* species, including many of the grass species present in prairies and CRP lands. Field surveys of *Poaceae* species were conducted in endangered Palouse Prairie and CRP habitats of southeastern Washington and adjacent northern Idaho, USA from 2010 to 2012 to examine for the presence of B/CYDV among plant hosts and aphid vectors. Viral species were identified via cloning and sequencing. Landscape, soil and climate data were retrieved from USDA-NASS and USDA-NRCS databases. Analyses were conducted to examine effects of diverse agroecological and environmental factors on virus prevalence. A total of 2271 grass samples representing 30 species were collected; 28 of these were infected with BYDV in at least one location. BYDV infection was detected at every CRP and prairie remnant sampled, with an overall infection of 46%. BYDV-SGV and BYDV-PAV were the only two B/CYDV species encountered, with BYDV-SGV being more prevalent. Sampling time (season) and host plant identity were the main variables explaining variation in virus prevalence among sites. BYDV was more prevalent in perennial compared to annual grass species. Aphids were encountered only once suggesting non-colonizing aphids, potentially from neighboring cereal fields, are responsible for disease spread in these habitats. BYDV prevalence increased in sampled habitats as cereal crop cover increased within a 1-km radius of a habitat patch. Results demonstrate moderate to high and persistent prevalence of BYDV in an endangered grassland habitat. Species composition and susceptibility to pathogens should be considered when creating seed mixes for CRP sites, especially in relation to agricultural crops and diseases in a region. Future work exploring host abundance, competence and habitat utilization by vectors is required to fully elucidate BYDV ecology and epidemiology in grassland habitats.

1. Introduction

Much of the landscape that was once dominated by native grasslands throughout the world has been transformed into agricultural production or developed as urban spaces. Grasslands are globally declining, leading to many of them becoming threatened and/or endangered habitats. For example, southeastern Washington and adjacent northern Idaho, USA, are home to the critically endangered Palouse prairie ecosystem which has historically been dominated by bunchgrasses, such as Idaho fescue (*Festuca idahoensis* Elmer) and bluebunch wheatgrass [*Pseudoroegneria spicata* (Pursh) Á. Löve] (Noss et al., 1995; Lichtardt and Moseley, 1997; Donovan et al., 2009; Scheinost et al., 2009). The prairie that once dominated the Palouse landscape is now reduced to small remnants (< 2 ha) located in areas that could not be farmed and are mostly privately owned (Hanson et al., 2008; Donovan et al., 2009; Looney and Eigenbrode, 2012). Less than 0.1% of the historical prairie habitat remains (Noss et al., 1995; Black et al., 2000). Preservation of these natural habitats is important not only to retain the unique species that occur in them, but also to preserve the ecosystem services they provide, such as mitigation of greenhouse

* Corresponding author at: Purdue University, Dept. of Entomology, 901 W State St., West Lafayette, IN 47907, USA.
E-mail address: lingwell@purdue.edu (L.L. Ingwell).

http://dx.doi.org/10.1016/j.virusres.2017.04.010
Received 13 October 2016; Received in revised form 27 March 2017; Accepted 12 April 2017

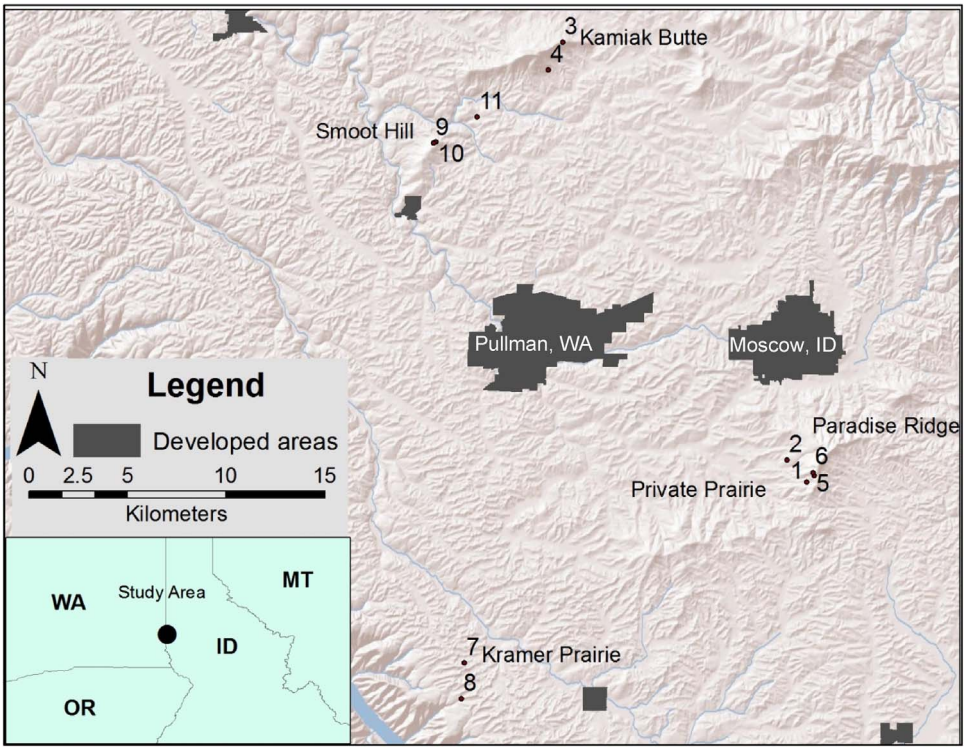

Fig. 1. Map of locations at which samples were collected. 1, Clyde Prairie; 2, Clyde CRP; 3. Kamiak Butte Prairie; 4. Kamiak Butte CRP; 5. Paradise Ridge Prairie; 6. Paradise Ridge CRP; 7. Kramer Prairie; 8. Kramer CRP; 9. Smoot Hill Prairie; 10. Smoot Hill Upper CRP; 11. Smoot Hill Lower CRP.

gases and habitat for pollinators and predatory insects. One important and understudied factor that influences the integrity of these habitats is plant pathogen prevalence.

Yellow dwarf disease is one of the most economically important diseases of cereal crops globally (Plumb, 1983), affecting wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.) and many other *Poaceae* species worldwide (D'Arcy, 1995). It is caused by a complex of viruses belonging to the family *Luteoviridae* referred to as *Barley* or *Cereal yellow dwarf virus* (B/CYDV) (Fauquet et al., 2005). B/CYDV are transmitted exclusively by aphids in a persistent circulative manner (Gildow, 1993), they are not transmitted mechanically or through seed. At least 25 species of aphids are reported as vectors of B/CYDV (Halbert and Voegtlin, 1995). This pathosystem has served as a model when examining the dynamics of insect-borne plant pathogens between agricultural and adjacent habitats (Jones, 2004; Vincent et al., 2014) and among species in pastures and nonmanaged grasslands (Coutts and Jones, 2002; Borer et al., 2007; Power et al., 2011; Jones 2013).

In one well-studied nonmanaged system, BYDV infection was prevalent among many of the grass species in California grasslands (Grafton et al., 1982). A survey in 1990 revealed that 37 of 56 cool-season grass species were infected with BYDV in California (Griesbach et al., 1990). BYDV has also been shown to play an important role in the competitive dynamics of native and invasive grasses in these communities (Malmstrom et al., 2005a,b; Borer et al., 2007). The presence of exotic annuals increases the prevalence of virus infection and lowers the competitive ability of native grass species. Native perennial grasses dominate in the absence of disease because they outcompete annuals for light, nutrients and water, however when BYDV is present in the system exotic annual grasses are able to establish and coexist with the native perennials (Borer et al., 2007). Infection of B/CYDV in conjunction with environmental factors reduces plant fitness (Seabloom et al., 2009) ultimately altering competitive dynamics.

Across a landscape, natural grasslands may contribute to virus outbreaks in surrounding agricultural fields or they often harbor their own community of pests and pathogens distinct from the surrounding agricultural crops. Perennial grasses serve as a reservoir of virus inoculum for annual species and emerging agricultural crops. Our knowledge and understanding of insect vector movement between agricultural and natural landscapes is limited. Some studies suggest that viral species do not overlap between these two ecosystems, indicating distinct pathosystems (Garrett et al., 2004), while others document overlap in the virus species present in agricultural and adjacent landscapes suggesting vector utilization of both habitats (Jones et al., 1990; Malmstrom, 1998). Furthermore, work in perennial mixed-species pastures has shown how plant age, community composition and vector populations can influence the identity and prevalence of viral species (Coutts and Jones, 2002; Jones, 2013) and is relevant to nonmanaged grasslands.

To better understand the ecology and epidemiology of B/CYDV among cropping systems, potential reservoir hosts need to be identified. Furthermore, to manage and conserve endangered grasslands a better understanding of the interactions among members of the plant community, including pathogens, is required. Therefore, the overall objective of this study was to examine nonmanaged grasslands in an agricultural matrix to gain a better understanding of the prevalence of agriculturally-important pathogens in habitats of conservation importance. We asked the following questions:

1. Are B/CYDV present in Palouse Prairie and conservation reserve program (CRP) habitats? If so, what are the prevalence, B/CYDV species present and potential aphid vectors in these habitats?
2. Is B/CYDV prevalence influenced by year, season, host type, site location and site type (CRP vs. prairie)?
3. Does host community composition vary among year, season, site location and site type (CRP vs. prairie)?
4. What is the importance of host community composition relative to the effect of year, season, site location, site type, and host type on B/CYDV prevalence?
5. Is B/CYDV prevalence in CRP and prairie habitats influenced by landscape factors, such as presence of cereal crops nearby?
6. Is B/CYDV prevalence altered by site-specific climate and soil variables?