IPM in potatoes: predicting phenology of four hemipteran pests in the lower Columbia Basin

Tiziana Oppedisano[1], Govinda Shrestha[1], Sarah Anderson[2], Ira D. Thompson[1], and Silvia I. Rondon[1,3]

[1]Hermiston Agricultural Research and Extension Center, Oregon State University, Hermiston, OR;
[2]Anderson Geographics LLC, Hermiston, OR; [3]Oregon Integrated Pest Management Center, Oregon State University, Corvallis, OR.

IRRIGATED AGRICULTURAL ENTOMOLOGY PROGRAM

Background

Potatoes are one of the most important economic crops in the United States. Several **hemipterans** affect potatoes, causing direct foliage damage or vectoring plant pathogens. Among them, ***Circulifer tenellus*** (Beet leafhopper) which is the vector of *Beet Leafhopper Transmitted Virescence Agent*, a phytoplasma causing Purple top disease; ***Lygus* spp.** which cause feeding damage; ***Myzus persicae*** (Green peach aphid) and ***Macrosiphum euphorbiae*** (Potato aphid) which are vectors of the *Potato virus Y* and *Potato leafroll virus,* are some of the most important pests (Fig. 1).

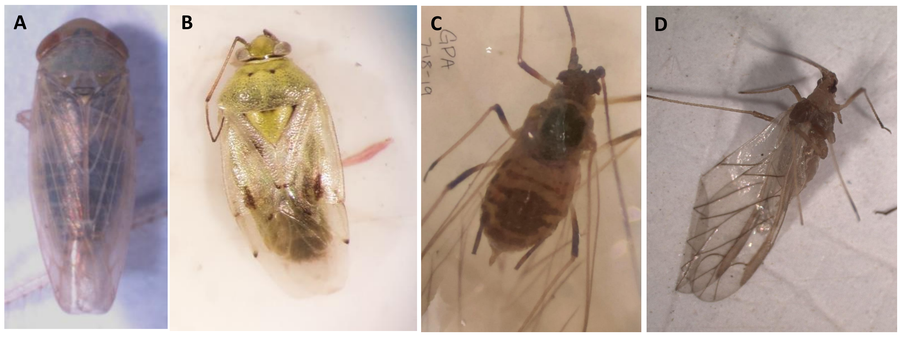


Figure 1. Hemipteran pests of potatoes **A.** *Circulifer tenellus* **B.** *Lygus* spp., **C.** *Myzus persicae* **D.** *Macrosiphum euphorbiae.*

Materials and Methods

POTATO PESTS MONITORING

Monitoring involved a weekly sampling of 30-37 commercial potato fields in eastern **Oregon**. We collected data since 2006 (*C. tenellus*), 2016 (*Lygus* spp.), and 2015 (*M. persicae* and *M. euphorbiae*) through 2019 (Table 1).

APPLICATION OF MODELS

The accumulated degree-days for each field site in each week was calculated using the rectangular method proposed by Herms (2004; Fig. 3). The association between accumulated **degree-days** and **potato-days** and total emergence percentage of each pest was modeled applying the Weibull distribution (Rinne 2008; Fig. 4).

Figure 2. Distribution of potato fields monitored weekly in the lower Columbia Basin.

$$\mathrm{DD} = \frac{T_{max} + T_{min}}{2} - T_{base}$$

Figure 3. Calculation of accumulated degree-days (DD). *Tmax* is the mean daily maximum temperature, *Tmin* is the mean daily minimum temperature, and *Tbase* is the insect lower developmental threshold. We used January 1st (T_0) of each year as a biofix date to calculate the DD.

$$y = a\left[1 - e^{-\left|\frac{x - x_0 + bln(2)^{\frac{1}{c}}}{b}\right|^c}\right]$$

Figure 4. Weibull distribution. *y* is the total emergence percentage, *x* the time in cumulative DD, x_0 for the time in DD required to reach 50% of emergence, and *a*, *b*, and *c* are empirically derived constants.

Insect pest	Year	Calendar date: Cumulative emergence based on degree days		
		10%	50%	90%
Circulifer tenellus	2019	21-24 May	4-5 Jul	30-31 Aug
	2018	17-19 May	2-4 Jul	21-23 Aug
	2017	28-30 May	7-9 Jul	28-29 Aug
	2016	6-7 May	26-27 Jul	19-23 Aug
	2015	13-14 May	22 Jun	10 Aug
	2014	18-20 May	2-4 Jul	18-21 Aug
	2013	15-16 May	3-4 Jul	24-25 Aug
	2012	27-29 May	12-14 Jul	7-8 Sep
	2011	11-16 Jun	25-29 Jul	25-27 Sep
	2010	3-6 Jun	17-20 Jul	18-22 Sep
	2009	29-31 May	8-11 Jul	29 Aug-2 Sep
	2008	31 May-7 Jun	13-16 Jul	14-18 Sep
	2007	19-24 May	5-7 Jul	29 Aug-1 Sep
	2006	24-28 May	7-9 Jul	29 Aug-1 Sep
Lygus spp.	2019	24-28 May	11-15 Jul	17-24 Aug
	2018	20-23 May	11-14 Jul	11-17 Aug
	2017	1-6 Jun	15-22 Jul	18-29 Aug
	2016	14-16 May	6-8 Jul	16-17 Aug
Myzus persicae	2019	24-May	16-17 Jul	3-4 Oct
	2018	10-11 May	6-7 Jul	15-17 Sep
	2017	26-27 May	11-14 Jul	26-27 Sep
	2016	30 Apr-2 May	28-29 Jun	22-24 Aug
	2015	3-4 May	26-27 Jun	2-3 Sep
Macrosiphum euphorbiae	2019	23-May	30 Jun-2 Jul	11-12 Sep
	2018	9-May	20-Jun	28-30 Aug
	2017	23-25 May	1-2 Jul	5-6 Sep
	2016	27-29 Apr	10-12 Jun	22-24 Aug
	2015	1-2 May	11-12 Jun	17-18 Aug

Table 1. Cumulative pest emergence percentages matched with calendar dates and years of study based on accumulated degree-days.

Results

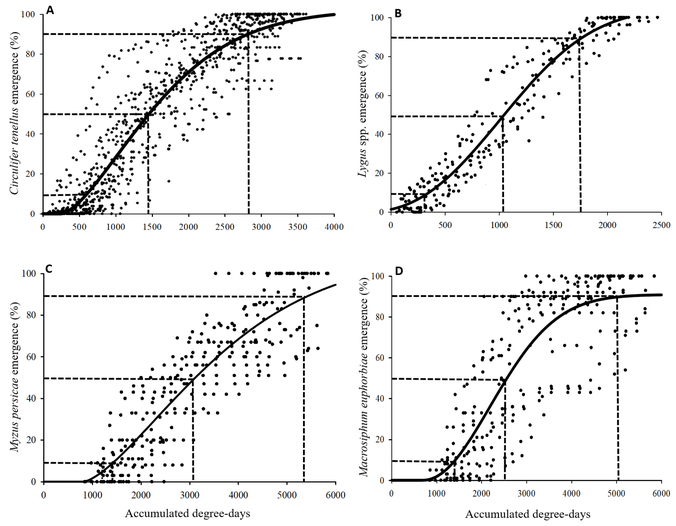


Figure 5. Cumulative emergence percentages of (A) *Circulifer tenellus*, (B) *Lygus* spp. (C) *Myzus persicae* (D) *Macrosiphum euphorbiae* on accumulated degree-days (DD). We used January 1st of each year as a biofix date to calculate the accumulated DD.

DEGREE-DAYS MODEL

- *Circulifer tenellus* population emergence occurred gradually at 582, 1,440, and 2,823 DD, corresponding to 10, 50, and 90%, respectively (Fig. 5A).
- Emergence of *Lygus* spp. increased in a relatively short period, with 10% of the population collected by 338 DD, 50% by 1,062 DD, and 90% by 1,776 DD (Fig. 5B).
- *Myzus persicae* population emergence occurred at 1,407, 3,058, and 5,590 DD, corresponding to 10, 50, and 90%, respectively (Fig. 5C).
- While for *M. euphorbiae*, 10, 50, and 90% of the populations were collected by 1,386, 2,557, and 5,047 DD, respectively (Fig. 5D).

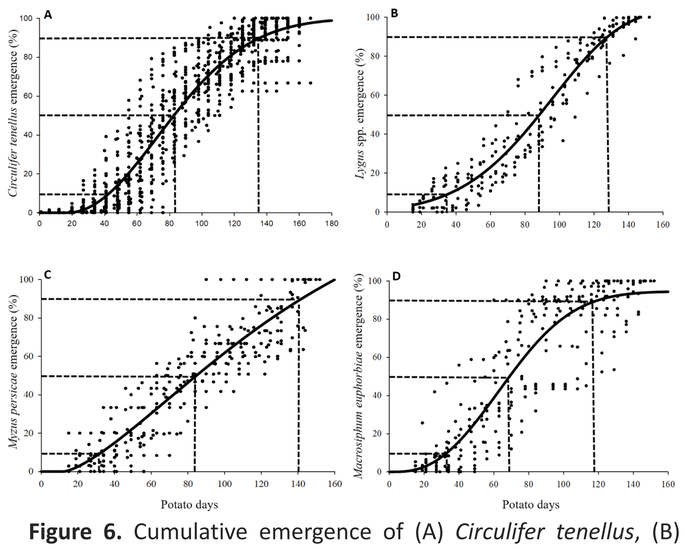


Figure 6. Cumulative emergence of (A) *Circulifer tenellus*, (B) *Lygus* spp. (C) *Myzus persicae* and (D) *Macrosiphum euphorbiae* on potato days (PD) after planting. Potato growth stages (sprout development: 0-30 PD; vegetative: 31-55 PD; tuber initiation: 56-75 PD; tuber growth: 76-125 PD; maturation: >126 PD).

POTATO-DAYS MODEL

- The emergence of all four hemipteran pests occurred during the vegetative growth stage.
- *C. tenellus* population emergence occurred 43, 84, and 136 DAP, corresponding to 10, 50, and 90%, respectively (Fig. 6A).
- *Lygus* spp. were collected 10% by 37 DAP, 50% by 86 DAP, and 90% by 127 DAP (Fig. 6B).
- The emergence of *M. persicae* occurred at 33 DAP (10%), 85 DAP (50%), and 142 DAP (90%) (Fig. 6C).
- While *M. euphorbiae* population was collected at 10, 50, and 90% by 34, 70, and 118 DAP, respectively (Fig. 6D).

Discussion

- Besides temperature, the availability of a preferred host (sugar beet) is likely to trigger *C. tenellus* to become active early in the season, as showed by D'Auria et al. (2016) for the upper Columbia Basin. Potato Purple top symptoms are found in the field as early as the beginning of July, meaning that the transmission may have occurred mid-June. Potato growers should manage the beet leafhopper between 500 and 1000 DD (percentage emergence 10% and <50%).
- Potato plants are more susceptible to virus infections in mid-July (85 DAP) for *M. persicae*, and late June (70 DAP) for *M. euphorbiae*, since we collected at those DAP the 50% of the two species. Potato plants likely are less susceptible to virus infections during crop maturing stage, which is reached around the time of 90% emergence of aphids' population in our study.

Conclusions

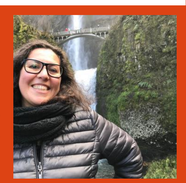
- Degree-days and Potato-days models can be useful in timing scouting events to monitor and prevent pest and insect-vectored pathogens outbreaks.
- Both models provide integrated pest management tools to potato growers for predicting pest timing and pairing that with strategic chemical applications.

References

Herms, D. A. 2004. Using degree-days and plant phenology to predict pest activity. IPM (integrated pest management) of midwest landscapes: 49-59.
Rinne, H. 2008. The Weibull distribution: a handbook, CRC press.
D'Auria, E. M., C. H. Wohleb, T. D. Waters, and D. W. Crowder. 2016. Seasonal population dynamics of three potato pests in Washington state. Environmental entomology 45: 781-789.

Presented data published in Oppedisano T., Shrestha G., Anderson S., Thompson D.I., Rondon S.I. (2022). Forecasting pest phenology of four major hemipteran pests to enhance integrated pest management programs in potatoes in the Columbia Basin. *Journal of Economic Entomology*. DOI 10.1093/jee/toab215.

Acknowledgments

Oregon Potatoes

Tiziana Oppedisano, Ph.D.
Hermiston Agricultural Research and Extension Center
Oregon State University
Hermiston, OR
Phone: (541) 567-6337 Ext. 117 or 124
Email: oppedist@oregonstate.edu