**Research Proposal Submitted to the Northwest Potato Research Consortium**

**Fiscal Year 2023-24**

**Proposal Title**: Maintenance of late blight of potato forecasts

**Principal investigator and co-PIs:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Address** | **Phone number** | **Email address** |
| Timothy Paulitz | USDA-ARS | 509-335-7077 | [paulitz@wsu.edu](mailto:paulitz@wsu.edu) |
| Carrie Wohleb | Washington State University | 509-707-3510 | [cwohleb@wsu.edu](mailto:cynthia.gleason@wsu.edu) |
| Tim Waters | Washington State University | 509-545-3511 | [twaters@wsu.edu](mailto:twaters@wsu.edu) |

**Total Funds Requested**: $13,201

Principal investigator portion: 13,201

Co-PI portion(s): $150

Second, third or more year funding request? x Yes No

**If Yes**, prior year(s) amount(s) funded:

2022-23: $ 12,892

2021-22:

**Research Plan**

**Summary of problem**

Late blight of potato, caused by *Phytophthora infestans*, has caused epidemics in the Columbia basin of Washington at least since 1947 (Anonymous, 1947). After this first recorded epidemic, it was not until 1990 that yearly epidemics consistently compromised potato crops (Johnson, 1996). To manage late blight effectively in potato crops, efficacious fungicides are applied. The cost of these fungicides varies from year to year. In 1998, for example, $22.3 million was spent on state-wide management of late blight (Johnson *et al.* 2000). For 2020, this translates into $35.3 million dollars. To reduce this cost, yield losses, and the risks that strains of *P. infestans* will develop fungicide resistance, accurate forecasts are required.

Late blight forecasts for the Columbia Basin of Washington were first implemented in 1993 by Johnson et al. (1996) following observations by Easton (1982). At first the risk of late blight in a given year was predicted based on the occurrence of late blight in previous years and the number of rainy days in April, May, July, and August for Prosser, Washington (Johnson, 1996). The models were subsequently expanded to include precipitation data from Hanford and Othello, Washington, as well as Hermiston, Oregon (Johnson et al. 1998). Lastly, solar irradiance, the number of cloudy days without rain, and the number of days since the first occurrence of late blight were used to increase the predictive performance of the late blight forecasting models by Johnson et al. (2009). Since the development of these models and deployment of recommendations via a website, phoneline, and emails, stakeholders came to depend on the weekly forecasts.

From 1993-2018, these forecasts were delivered by Dr. Dennis Johnson and colleagues without formal financial support. Upon Johnson’s retirement in 2018, Dr. Gary Grove and colleagues issued forecasts and recommendations. In 2020 and 2021, Dr. Wheeler issued forecasts and recommendations. Further, upon Dr. Wheeler’s resignation in 2022, Dr. Paulitz took over the project and issued forecasts for 2022 growing season. For these late blight forecasts to be sustainable, minimal financial support is needed to fund rain forecasts, support travel to and from infested fields, and diagnostics to confirm late blight presence or absence. **From this support, weekly late blight forecasts, recommendations, travel to and from potentially infested fields or storage sheds throughout the growing season, and diagnostics will be provided.** In the long-term, late blight forecasts will be improved to include weather data from various representative potato production regions in Washington and the PNW at large and pathogen abundance data from strategically placed spore traps. Ultimately, this network could serve as an extension of the UI network and produce forecasts and recommendations for various economically important diseases.

**Research Objectives**

The goal of this project is to minimize late blight outbreaks in Washington and maintain the infrastructure needed to support management decisions and diagnostics. To accomplish this goal, the following objectives will be completed in the 2023-2024 funding year.

**Objectives:**

1. Produce late blight forecasts and recommendations
2. Inspect and collect samples from fields with reports of late blight.
3. Confirm late blight presence with diagnostics and, if necessary, genetic testing.

[**Experimental Approach**](https://docs.google.com/document/d/1AIU3Ve4R6-CSBYSVoQW3URErWOvV4YyACLp5Twgwks0/edit)

**Objective 1** will be completed by the Drs. Paulitz and Wohleb during the 2023-2024 funding year. Late blight forecasts will be produced using the same methods as Johnson and colleagues. Starting in May and proceeding until September weekly late blight forecasts will be produced using weather forecasts and the models developed by Johnson et al. (1998). Rain forecasts for Prosser, Othello, and Tri-Cities will be used as inputs into Johnson et al.’s model. These models use the product of 5 risk factors to determine the appropriate recommendations for the risk of late blight.

The first risk factor is crop phenology. Phenology data is collected by collaborators across the Columbia Basin and is vital since late blight has only ever occurred in the Columbia Basin after row closure. The second risk factor is the presence or absence of late blight in adjacent fields. If *P. infestans* is nearby, the risk that it will infest proximate fields is higher than if *P. infestans* is absent. The third risk factor is the probability that late blight will occur in Prosser, Othello, and Tri-Cities. These probabilities are calculated from the models developed by Johnson et al. (1998). The probability of the annual occurrence of late blight is modeled as a function of the presence of late blight the previous year as well as the number of rainy days during the spring and summer (Johnson et al. 1996). Probabilities for each location are issued weekly with forecasts and recommendations in the WSU Potato Pest Alerts by PI Dr. Carrie Wohleb. The fourth risk factor is the date. The date is important because the potato canopy is more conducive to late blight in June than in May, July or August (Johnson and Cummings, 2016). Finally, the fifth risk factor is number of rainy days expected in the next 7 days. These fine scale weather data are important because late blight develops faster under wet and cool weather conditions than in hot and dry conditions. Together the product of these risk factors is used to determine weekly recommendations for growers.

**Objective 2** will be completed by all PIs during the 2023-2024 funding year. Drs. Wohleb and Waters will likely be the first informed about late blight outbreaks since they have established extensive networks with the growers and are stationed in the Columbia Basin. Drs. Waters and Wohleb will then inform T. Paulitz, who will visit the fields and collect samples. If circumstances arise that constrain T. Paulitz from visiting a field(s) then the other PIs will mail him samples. Finally, **objective 3** will be completed by T. Paulitz during the 2023-2024 funding year. Samples will be incubated in artificial conditions to encourage growth of *P. infestans*.The pathogen will then be isolated and identified with genetic markers.

**Collaboration:** Weather forecasts will be obtained from Fox Weather LLC (the same company that provided weather forecasts for Drs. Johnson, Grove and Wheeler). T. Paulitz will produce late blight forecasts and recommendations for objective 1. C Wohleb will then disseminate the forecast and recommendations via WSU’s Potato Pest Alert system. T Waters and C Wohleb will serve as the eyes on the ground for late blight in the Columbia Basin. When outbreaks occur, samples will be collected by C Wohleb, T Waters, and T. Paulitz. T. Paulitz and SGC Upadhaya will isolate *P. infestans* from infested plant debris and genotype isolates.

Expected outcomes for this project include (i) weekly late blight forecasts and recommendations issued via WSU’s Potato Pest Alert system from May to September of 2023, and (ii) late blight prevalence and *P. infestans* genotypic data from outbreaks in Washington.

**Budget:** Please provide the following in a table format as shown, listing only the budget items appropriate for your project. Add columns or tables as needed to accommodate all scientists/labs seeking funding under this project. Add or subtract footnotes or addenda to the budget table as needed to fully explain your plans or needs. More detail is better than less. Personalize the budget table with the names of each funded scientist at the tops of the columns, delete unneeded rows/columns, and delete these instructions.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **FY 2023-24** | **Paulitz lab** | **Wohleb Lab** | **Waters Lab** | **Total** |
| **1Salaries: Graduate Student** | $5,218 |  |  | $5,218 |
| Other students |  |  |  |  |
| **2Benefits (OPE): Graduate Student** | $482 |  |  | $482 |
| **Operating Expenses** |  |  |  |  |
| Weather forecasts from Fox Weather LLC | $4,800 |  |  | $4,800 |
| Travel | $1,000 |  |  | $1,000 |
| Sampling |  |  |  |  |
| Shipping samples |  |  | $150 | $150 |
| Culturing *Phytophthora infestans* from plant debris | $200 |  |  | $200 |
| DNA extraction and sequencing | $1,500 |  |  | $1,500 |
| **Total** | 13,200 | $0 | $150 | $13,350 |

1Salary to support graduate student for 0.175 FTE of 9 months

2 Benefits for graduate student are 15.4% of salary

**Anticipated Total Requests in Coming Years: 2024-2025: $0**

**Other Support of Project, Anticipated Supporting Grant Applications:**

Other support for this project comes from state-based and federal funds in the form of salaries and benefits for project investigators, Tim Paulitz, Carrie Wohleb, and Tim Waters. This project will serve to produce data for larger regional grants like the USDA Sustainable Agriculture Research and Extension and Western IPM.

**Progress Report**: (one page or less)

The goal of this project is to assist potato growers in the Columbia Basin of Washington make informed late blight management decisions. It aims is to minimize late blight outbreaks in Washington and maintain the necessary infrastructure to support management decisions and diagnostics. To achieve this, as in previous years, late blight forecasts were generated weekly for three regions, TriCities, Othello and Prosser during potato growing season. More specifically, starting the first of May until the third week of September 2022, weather forecast data was obtained from the Fox Weather Station. Thus, obtained weather data were used in a model developed by Johnson et al. 1998 to calculate the probability of late blight occurrence for the given week. Further, late blight risk was calculated by taking product of five risk factors, such as crop phenology, previous report of late blight, date, number of rainy days forecasted and probability of late blight occurrence. The obtained risk factor was then used to determine weekly recommendations for growers. The weekly forecasts and recommendations were posed on our [project site](https://d-linnard.github.io/LateBlight/) and shared by Dr. Wohleb via WSU’s Potato Alerts. A glimpse of the Potato Pest Alert report is below. The project was completed on late September 2022.

Despite the extremely favorable environmental conditions, with extremely wet May and June, no late blight disease was reported nor observed by the PIs during 2022 growing season from Columbia Basin region. Therefore, PIs didn’t carry out objective 2 and 3. However, provisions were made to do race and genotyping in case the disease exploded. The PIs contacted other researchers in OR and NC who could help with the genotyping.

Graphical user interface, text, application, email

Description automatically generated

**Timothy D. Waters**

404 W. Clark, Pasco, WA 99301-3706

Phone: (509) 545-3511 ext. 6001 Email: [twaters@wsu.edu](mailto:twaters@wsu.edu)

**Positions and Employment**

Year Organization Position

2018 – Washington State University Professor/Regional Vegetable  
County Extension Specialist and Franklin County Director

2006 – 2018 Washington State University Associate Professor/Regional Vegetable  
County Extension Specialist and Franklin County Director

**Honors and Awards**

2016 CAHNRS Excellence in Extension Award

2012 CAHNRS Team Excellence Award for the PNW Vegetable Extension Group

2010 Achievement Award. National Association of County Agricultural Agents.

2007 Team award for Integrated Pest Management. Entomological Society of America

**Synergistic Activities**

I serve as the Regional Vegetable Specialist for commercial vegetables in Franklin and Benton Counties of Washington State. As an educational leader, teacher, manager, and board member, I sponsor various meetings, workshops, and newsletters for several industry organizations. Additionally, I perform applied research experiments on potatoes and commercial vegetables and share the results of these efforts via written publications and presentations at local, state, national, and international meetings. I also serve on the editorial advisory board of Vegetable Growers News and on the research review boards and conference planning committees for the Washington State Potato Commission and the Pacific Northwest Vegetable Association.

**Publications**

Selected Professional Articles, Refereed or Peer Reviewed

Horton, D. R., Miliczky, E., Waters, T.D., Burckhardt, D., Halbert, S. (2021). Exotic Psyllids and Exotic Hosts: Accumulation of Non-native Psylloidea in North America (Hemiptera). Annals of the Entomological Society of America, Volume 114, Issue 4, July 2021, Pages 425–447, https://doi.org/10.1093/aesa/saab014. (2,6).

Reyes Corral, C. A., Cooper, W.R., Horton, D., Miliczky, E., Riebe, J., Waters, T, Wildung, M., Karasev, A. (2021). Association of Bactericera cockerelli (Hemiptera: Triozidae) With the Perennial Weed Physalis longifolia (Solanales: Solanaceae) in the Potato-Growing Regions of Western Idaho, Environmental Entomology, Volume 50, Issue 6, December 2021, Pages 1416–1424, https://doi.org/10.1093/ee/nvab076. (2,6).

Wohleb, C.H., Waters, T.D. & Crowder, D.W. (2021). Decision Support for Potato Growers using a Pest Monitoring Network. Am. J. Potato Res. 98, 5–11. https://doi.org/10.1007/s12230-020-09813-0. (2,6).

Mishra, S., Dee, J., Moar, W., Dufner-Beattie, J., Baum, J., Diaz, N., Alyokhin, A., Buzza, A., Rondon, S., Clough, M., Menasha, S., Groves, R., Clements, J., Ostlie, K., Felton, G., Waters, T., Snyder, W., Jurat-Fuentes, J. (2021). Selection for high levels of resistance to double-stranded RNA (dsRNA) in Colorado potato beetles (Leptinotarsa decemlineata Say) using non-transformative foliar delivery. Scientific Reports. https://doi.org/10.1038/s41598-021-85876-1. (2,3,6).

du Toit, L.J., M. L. Derie, B. Gundersen, T.D. Waters, and J. Darner. (2021). Efficacy of disinfectants applied to onion bulbs in storage for control of bacterial bulb rots, Pasco, WA, 2020-2021. Plant Disease Management Reports 15.V102. (2,3,6).

du Toit, L.J., M. L. Derie, B. Gundersen, T.D. Waters, and J. Darner. (2021). Efficacy of late-season cultural practices on bacterial leaf blight and bulb rots in an onion bulb crop in Pasco, WA, 2020. Plant Disease Management Reports 15:V100. (2,3,6).

du Toit, L.J., Derie, M.L., Gundersen, B., Waters, T.D., and Darner, J. (2021). Efficacy of bactericides for management of bacterial leaf blight and bulb rots in an onion crop in Pasco, WA, 2020. Plant Disease Management Reports 15:V107. (2,3,6).

Miliczky, E. R., Horton, D. R., Waters, T. D., Wohleb, C. H. (2020). Observations on the life history and ecology of *Clubiona pacifica* Banks in Washington State (Araneae: Clubionidae). JOURNAL OF ARACHNOLOGY, 48(1), 49-58.

Cooper, W. R., Horton, D. R., Miliczky, E., Wohleb, C. H., Waters, T. D. (2019). The Weed Link in Zebra Chip Epidemiology: Suitability of Non-crop Solanaceae and Convolvulaceae to Potato Psyllid and "Candidatus Liberibacter Solanacearum". AMERICAN JOURNAL OF POTATO RESEARCH, 96(3), 262-271.

Horton, D. R., Kaur, N., Cooper, W. R., Miliczky, E., Badillo-Vargas, I. E., Esparza-Diaz, G., Rashed, A., Waters, T. D., Wohleb, C. H., Johnson, D. L., Kawchuk, L., Jensen, A. S. (2019). Whence and Whither the Convolvulus Psyllid? An Invasive Plant Leads to Diet and Range Expansion by a Native Insect Herbivore. Annals of the Entomological Society of America, 112(3), 249-264.

Horton, D., Miliczky, E., Lewis, T., Cooper, W., Waters, T., Wohleb, C., Zack, R., Johnson D., and Jensen, A. (2018). New North American Records for the Old World Psyllid Heterotrioza chenopodii (Reuter) (Hemiptera: Psylloidea: Triozidae) with Biological Observations. Proceedings of the Entomological Society of Washington, 120(1): 134-152.

Horton, D., Miliczky, E., Lewis, T., Wohleb, C., Waters, T., Dickens, A., . . . Jensen, A. (2019). Building a better Psylloidea (Hemiptera) trap? A field-look at a prototype trap constructed using three-dimensional printer technology. The Canadian Entomologist, 151(1), 115-129. doi:10.4039/tce.2018.59

Horton, D., Miliczky, E., Lewis, T., Cooper, W., Munyaneza, J., Mustafa, T., Thinakaran, J., Waters, T., Wohleb, C., and A. Jensen. (2017). New Geographic Records for the Neartic Psyllid *Bactericera maculipennis* (Crawford) with Biological Notes and Descriptions of the Egg and Fifth-Instar Nymph (Hemiptera: Psylloidea: Triozidae). Proceedings of the Entomological Society of Washington, 119 (2): 191-214.

D’Auria, E.M., Wohleb, C.H., Waters, T.D., and Crowder, D.W. (2016) Seasonal Population Dynamics of Three Potato Pests in Washington State. Environmental Entomology 45, 781-789.

**Extension Publications**

Waters, T. D. and C. H. Wohleb. (2016). Corn Earworm Pest of Sweet Corn. FS221E. pp 6. Pullman, WA: WSU Extension Publishing*.*

du Toit, L.J., Waters, T., and Reitz, S. (2016). Internal Dry Scale and Associated Bulb Rots of Onion. Extension Bulletin PNW 686.

**Timothy C. Paulitz**

**Research Plant Pathologist**

USDA-ARS Wheat Health, Genetics and Quality Research Unit

Washington State University, Pullman, WA 99164-6430

**ORCID:** **0000-0002-8885-3803.**

**EDUCATION**

University of California, Riverside, PhD in Plant Pathology 1984

California State Polytechnic University, Pomona, BS in Botany and Plant Pathology, 1979

**RESEARCH AND PROFESSIONAL EXPERIENCE**

2000-present. GS 15. USDA-ARS Wheat Health, Genetics, and Quality Research Unit, Pullman, WA. Research Plant Pathologist. Soilborne fungal and nematode diseases of wheat, barley, canola, legumes and other rotation crops. Epidemiology, ecology, detection and quantification of soilborne pathogens. Microbiome of wheat and rotation crops, soil health, soil microbiomes

1989-2000 Dept. Plant Science, Macdonald Campus of McGill University, Ste. Anne de Bellevue, Quebec, Canada. Assistant and Associate Professor. Plant pathology of cereal, fruit, vegetable crops and greenhouse crops. Mycology, ecology, epidemiology.

1987-1989. USDA-ARS Horticultural Research Laboratory, Postdoctoral Research Associate. Biological control of fungal diseases with antagonistic bacteria and interactions with vesicular-arbuscular mycorrhizal fungi.

1984-1987. Department of Plant Pathology and Weed Science, Colorado State University. Visiting assistant professor. Biological control of greenhouse crops.

**Relevant Professional Experience and Synergistic Activities**

2019-present Section Editor, Canadian Journal of Plant Pathology

2007-2016 Editor-in-Chief, American Phytopathological Society Press

2009 Fellow, American Phytopathological Society

2007-2012 Associate Editor-in-Chief, American Phytopathological Society Press

2004-2007 Senior Editor, American Phytopathological Society Press

2005-present Collaborator with CIMMYT Global Initiative on Wheat Root Health in Rainfed System, teaching workshops in Turkey and hosting Turkish, Moroccan and Tunisian scientists.

2002-present Member, secretary, and chair of W-3147 Biological Control of Soilborne Pathogens Multistate CSREES project

1999-2002 Member of U.S. Wheat and Barley Scab Initiative Review Panel

2001-present Section Editor, Canadian Journal of Plant Pathology

1998-2002 Section Editor, Plant and Soil

1994-1997 Senior Editor, Phytopathology

1991-1994 Associate Editor, Phytopathology

From 1990-2000, I supervised to completion 18 MSc students, 4 PhD students, and 5 postdoctoral researchers. From 2000-2022, as an adjunct professor in the Dept. of Plant Pathology at Washington State University, I have supervised or co-supervised 9 PhD and 3 MSc students.

**PUBLICATIONS** (**More than 175 refereed publications over career, 17 book chapters and over 80 abstracts). Refereed publications for the last year are presented.**

Yin, C., Casa Vargas, J.M., Schlatter, D.C. *et al.* Rhizosphere community selection reveals bacteria associated with reduced root disease. *Microbiome* **9,** 86 (2021). <https://doi.org/10.1186/s40168-020-00997-5>

Yin C, Schlatter DC, Kroese DR, Paulitz TC, Hagerty CH. Responses of Soil Fungal Communities to Lime Application in Wheat Fields in the Pacific Northwest. *Front Microbiol*. 2021;12:576763. Published 2021 May 20. doi:10.3389/fmicb.2021.57676342. <https://doi.org/10.3390/agriculture10100447>

Bozoglu, T., Ozer, G., Mustafa, I, Paulitz, T. and Dababat, A. 2021 First report of crown rot caused by *Fusarium redolens* in Kazakhastan. Plant Disease <https://doi.org/10.1094/PDIS-01-21-0015-PDN>

Imren, M. Ozer, G., Paulitz, T. and Dababat, A. 2021. Plant-parasitic nematode communities associated with wheat-growing areas in central,eastern, and south-eastern Kazakhstan. Plant Disease: https://doi.org/10.1094/PDIS-11-20-2424- SR.

Wang, Z, Schlatter, D., Glawe, D., Edwards, C., Weller, D., Paulitz, T., Abatzouglou, J. and Okukara, P. 2021. Native yeast and non-yeast fungal communities of Cabernet Sauvignon berries from two Washington State vineyards, and persistence in spontaneous fermentation, International Journal of Food Microbiology,

<https://doi.org/10.1016/j.ijfoodmicro.2021.109225>.

Schlatter, D. C, Hansen, J, Carlson, B., Leslie, I. N. Huggins, D. R. and Paultiz, T. C. 2022. Are microbial communities indicators of soil health in a dryland wheat cropping system? Applied Soil Ecology 170: 10.1016/j.apsoil.2021.104302

Yin, C. T., Schlatter, D. C., Kroese, D. R., Paulitz, T. C. and Hagerty, C.H. 2021. Responses of Soil Fungal Communities to Lime Application in Wheat Fields in the Pacific Northwest. Frontiers in Microbiology 10.3389/fmicb.2021.576763

Gargouri, S., Boutrous, A., Murray, T. D., Paulitz, T. C., Khemir, E., Souissi, A. Chekali, S. and Burgess, L. W. 2021. Occurrence of eyespot of cereals in Tunisia and identification of *Oculimacula* species and mating types. Canadian Journal of Plant Pathology 10.1080/07060661.2021.1995501

Hagerty, C., Gardner, S., Kroese, D.R., Yin, C., Paulitz, T.C., Pscheidt, J.W. 2022. Occurrence of mummy berry associated with huckleberry (*Vaccinium membranaceum*) caused by *Monilinia* spp. in Oregon. Plant Disease. 106(2):357-359. https://doi.org/10.1094/PDIS-04-21-0691-SC.

Ahmadi, M., Mirakhorli, N., Erginbas-Orakci, G., Ansari, O., Braun, H., Paulitz, T.C., Dababat, A. 2022. Interactions among cereal cyst nematode *Heterodera filipjevi,* dryland crown rot *Fusarium culmorum*, and drought on grain yield components and disease severity in bread wheat. Canadian Journal of Plant Pathology. 44(3):415-431. https://doi.org/10.1080/07060661.2021.2013947.