**Project Title: Integrated Management of Secondary Pests on Hops 2022**

**Project Summary:** Beyond the key arthropod pest of hops, spider mites, which are addressed in detail in a separate proposal, hops are plagued with a number of otherdirect and indirect arthropod pests. These include hop aphids and several caterpillars including the common grey, hop looper, and increasingly oblique banded leafroller. In this proposal we detail specific experiments we plan to improve management of several pests of hops in a biorational way. We will evaluate candidate insecticides for aphid control and quantify any adverse effects these insecticides have on the bioregulation of aphids and outbreak of spider mites. We also plan to screen cyantraniliprole, spinetoram, spinosad, and chlorantraniliprole for control of hop looper and other caterpillar pests as a replacement for bifenthrin and other disruptive insecticides. We will also continue to test the safety of candidate pesticides for their effects on essential predatory mites.

Collectively much of our efforts to replace disruptive pesticides with reduced risk and more targeted pest control chemistries are stymied when MRL issues in key target markets lead to hop growers being forbidden to apply improved pesticide chemistry. We propose to complete a comprehensive, controlled study on what actual residues exist on hops given an intensive, but realistic, use of candidate pesticide chemistry. New evidence has emerged that the application of ozonated water can break down pesticide residues. We plan to investigate if the application of ozonated water 1 or 2 days prior to harvest can reduce pesticide residues of key pesticides with MRL issues in target export markets.

Comprehensively we will continue to conduct our extensive outreach and engagement and to proactively support the hop industry in regulatory affairs.

**Proposed Duration:** Year 14 complete. Year 15 proposal.

**Project Leader:**

Douglas B. Walsh, Professor of Entomology

Washington State University

Irrigated Agriculture Research and Extension Center

24106 N. Bunn Rd., Prosser, WA 99350

509-786-9287, dwalsh@wsu.edu, http://ipm.wsu.edu

**Cooperators:**

Sally O’Neal, Sr. Extension Outreach Specialist David Gent, USDA-ARS

Dan Groenendale, Field Research Director Justin Clements, U of Idaho, Parma

**Amount Requested:**

$40,417 ($24,250 HRC and $16,167 from WA Hop Commission)

**Other Funding:**

1. Enhancing Supply Chain Sustainability and Global Competitiveness for Pacific Northwest Hops USDA-NIFA, Specialty Crop Research Initiative. $4,853,907. 10/1/21 through 9/30/25. Features the usual suspects among hop researchers and a few new scientists working on data analysis and project evaluation.

2. Washington State IPM Extension Implementation Program 2021-2024 USDA-CIFA CPPM

$757,206. 9/1/2021 through 8/31/2024. A substantial proportion of these funds are used to support Senior Communication Specialist Sally O’Neal. Extension in specialty crops including hops is an objective for this program and Ms. O’Neal will continue to participate with the hop industry in the production of outreach and educational outputs.

3. Evaluation and development of hop germplasm for the WA hop region. USDA-Pass Through for hop breeding 9/1/21 to 8/31/21. $74,449. These funds support IAREC Facility Hops Manager Mr. Dan Groenendale and Farmer II Mr. Tony Moreno at roughly 37.5% and 50% FTE, respectively. Some funds are provided for miscellaneous expenses, land use charges, local travel, maintenance pesticides, and miscellaneous hop growing supplies.

3. Washington State Commission on Pesticide Registration. I will submit a request of about $20,000 for their funding consideration using Washington Hop Commission and Hop Research Council funds as matching funds. The $20,000 in WSCPR funds received in 2021 funded have been expended on Mr. Tony Moreno and Mr. Miguel Leon’s salaries for September, October, and November 2020. We will ask for a renewal for 2022.

4. USDA-NIFA-IR-4. Magnitude of Residue and Product Efficacy Studies 2021.

9/1/20 to 8/31/21. $84,500. These funds are paid as piece work by IR-4 at $6,500 for each MOR study. In most years we have 2 to 4 MOR studies on hops. These funds are used primarily to cover salary and benefits costs for Ag Research Technologist III, Mr. Wilson Peng. Mr. Peng participates in pesticide application to hops and he completes pseudo-commercial pesticide residue trials at the direction of the Hop Industry Plant Protection Committee.

**Send Funding to:**

Samantha Bridger, Grants Administrator

WSU IAREC

24106 N. Bunn Rd

Prosser, WA 99350

Tel. 509.786.9204

Fax. 509.786.9370

Email [prosser.grants@wsu.edu](mailto:prosser.grants@wsu.edu)

**Project Title: Integrated Management of Secondary Pests and Augmented Releases of Predatory Mites on Hops**

**Statement of Problem:** As detailed in the Hop Research Council Research Priorities for research on hops from January 2021, this proposal directly addresses priority 2 of prioritized general research categories Insect Pest Research and specifically addresses priorities 1, 2, 3, 6, & 7 within the subcategory for “Insect Pest Research” by conducting research to develop and refine control strategies for the hop aphid and several pest caterpillars. Additionally, Project Leader Walsh has served for many years as liaison between the USDA-IR-4 pesticide registration program and the US hop industry and in the process has assisted the hop industry in becoming the specialty crop with access to the most advanced crop protection chemistries. Unfortunately, hop growers are often forbidden to use these targeted and reduced risk pesticides in hops grown for export markets due to Maximum Residue Level (MRL) issues and hop merchant-imposed restrictions. IR-4 develops US tolerances based on the use of a pesticide at its maximum rate, applied the maximum number of times proposed on the label, with the crop being harvested at its minimum pre-harvest interval (PHI). This results in the greatest quantity of pesticide residue that could conceivably be on the harvested crop. The US tolerance (equivalent to MRL) is then set above these detected residue levels from scrutinized IR-4 residue trials to ensure that the residues of a pesticide on hops never exceeds the tolerance. Rarely will growers apply a pesticide the maximum number of permitted applications at the maximum label rate at the shortest PHI. We propose to continue to run comprehensive residue trials with most of the commonly used pesticides under use patterns that are intensive but realistic and develop residue decline tables for use by the hop industry.

Recent studies in several crops and in stored products have demonstrated that the application of ozonated water has reduced the pesticide residues on the target crops. We have access via the WSU Center of Precision and Automated Agricultural Systems to an airblast sprayer that is set up to apply ozonated water. We will incorporate this technology into our ongoing research on pesticide residues to quantify if use of this ozonating technology can indeed reduce pesticide residues on harvested hops.

**Justification and Importance of Proposed Research:** Feeding by and/or contamination of hops by infestation of arthropod pests reduces crop value. The work detailed in this proposal will focus on providing the information required to make recommendations for the evolving hop IPM program. We will evaluate several candidate insecticides for control of aphids and caterpillar pests. Cohesively among all of our studies we will consider and evaluate the impact beneficial organisms are providing towards the bioregulation of the pest insects listed above. We will continue our program of evaluating the impact candidate chemistries on predatory mites.

In 2020 there were 58,641 acres of hops harvested in the PNW. Yields were below average at 1,770 pounds per acre. Prices remained high and gross returns were calculated to be $10,563 per acre. It is difficult to quantify acreage impacted by each of these pests as well as to quantify loss of crop value, but when populations of these pests are detected, risk-averse growers tend to apply insecticides. MRL issues have inhibited the application of recently registered biorational insecticides and unfortunately the broad-spectrum disruptive insecticide bifenthrin is used. Some merchants have reduced restrictions on chlorantraniliprole. Cyantraniliprole has great prospects for caterpillar control and cyantraniliprole is a high priority for hop growers in the EU, so MRL issues could potentially be overcome quickly. Other reduced risk pesticides will be incorporated into our comprehensive residue program. MRLs in key target markets, most notably the European Union, will continue to be of paramount importance for the hop industry. Our comprehensive residue studies coupled with the emerging technology of using ozonated water treatments could lead to reduced pesticide residues on hops and lead to decreased restrictions on hop growers’ ability to apply pesticides that are completely permitted and legal to apply but are forbidden by hop merchant restrictions.

**Objectives:**

a) Field test candidate insecticides for their efficacy against aphids and impacts on beneficial arthropods on research plots located at IAREC near Prosser, WA. (ongoing objective)

b) Field test efficacy of insecticides on other pests if opportunities arise. (ongoing objective)

c) Field test candidate insecticides for control of pest caterpillars. (ongoing objective)

d) Evaluate impact of candidate pesticides on beneficial mites. (ongoing objective)

e) Investigate factors contributing to export market viability for U.S. hops, including anticipated loss or lack of MRLs for key pest management tools in key export markets. (Year 2 of 5)

f) Test the application of ozonated water via airblast sprayer towards reducing pesticide residues. (Year 1 of 3)

**Procedures/Methods to Accomplish Objectives:**

**a) Aphicide efficacy and impacts.** Research plots will be set up in hop yards on the WSU Prosser Irrigated Agriculture Research and Extension Center (IAREC). We anticipate receiving several protocols this year from registrants with candidate numbered compounds. These protocols will be followed to the best of our ability. Additional compounds that will be screened for efficacy against aphids will include sulfoxaflor, imidacloprid, and cyantraniliprole. If no protocols are received, published and/or registered label rates from other registered crops will be applied. Plots will be established in late spring or early summer. All applications will be made by airblast sprayer. Ten to fifteen leaves will be collected from each plot once per week and transported to the laboratory, where the number of aphids and other relevant pest and beneficial arthropods will be quantified. Additionally, the number of aphids that are parasitized will be counted to calculate percent parasitism. Aphid and other arthropod populations from treated plots will be compared with those from nontreated control plots. Aphid abundance will be analyzed by repeated measures analysis of variance and population means of aphids in treated plots will be compared in pairwise tests with populations in the untreated control plots.

**b) Pesticide tests on other pests.** As part of our ongoing commitment to service to the hop industry, we include this objective annually at no charge, reflecting our willingness and ability to rise to the occasion should an unanticipated pest pose a problem during the project year.

**c) Insecticide trials on caterpillars.** If we become aware of a hop yard in which sufficient populations of pest caterpillars develop, we will conduct an insecticide efficacy trial with the candidate insecticides spinetoram, chlorantraniliprole, cyantraniliprole, *Bacillus thuringiensis* and emamectin benzoate. Bifenthrin will serve as the standard. Plot size and configuration will depend on the site. We will monitor the plots before and post treatment by shaking 10 individual hop vines into our 0.5m2 research funnel. The caterpillars and other arthropods that drop from the canopy into the funnel will be swept into a jar of 70% alcohol. The jars will be transported to the Hop Research Facility located at IAREC and the arthropods captured will be identified and quantified. Resulting data will be analyzed and recommendations developed.

**d) Pesticide impacts on beneficial mites.** Predatory mite colonies have been established and will continue to be maintained at the Hop Research Facility in Prosser. A list of candidate insecticides and miticides that require pesticide safety studies will be determined in communication with the Hop Industry Plant Protection Committee. We are going to suggest looking at several aphid control chemistries that include candidate lipid biosynthesis inhibitors as well as some of the alternative acaricides that will be field tested and analyzed in the laboratory as detailed in our companion proposal to the HRC for research on spider mites. The predatory mites will be topically exposed in a Potter spray tower to dilute sprays of each candidate chemistry at decreasing concentrations. These tests will be used to refine our ongoing list of agricultural chemicals deemed safe or dangerous to beneficial mites.

**e) Export viability / pesticide residues.** U.S. hop growers are facing nothing short of a crisis regarding export markets, a vital component of the industry’s profitability. The fungicide quinoxyfen, the suite of neonicotinoid insecticides (e.g., imidacloprid, thiamethoxam), and the acaricide spirodiclofen are among compounds considered essential to the U.S. hop grower, but facing increased scrutiny in export markets, most notably the European Union. To address current and anticipated MRL restrictions on hop exports, we will conduct a third year of experimental plot studies to identify alternative pesticides and use patterns. We will conduct a series of residue studies based out of research hop yards at the WSU Prosser Irrigated Agriculture Research and Extension Center. We anticipate these studies may take up to 5 years. In 2020 and 2021, a wide variety of pesticides (25, including quinoxyfen, imidacloprid, spiromesifen, and acequinocyl) were applied to our research hop yards at rates, timings, and frequencies typically employed by growers. This differed from the IR-4 program’s protocol of applying at the maximum rate for the maximum number of allowable applications when conducting magnitude of pesticide residue trials as part of their petition to the U.S. EPA to establish pesticide tolerances (MRLs) on specialty crops. Presently (as of September 1, 2021), we are harvesting hops from these research plots and cone samples will be sent to Pacific Analytical for pesticide residue analysis using methods designed to detect multiple residues (Hengel et al. 2016, 2018). Those pesticides with detectable residues above the default or established MRL for key export markets will be included in 2022 studies, in which the pre-harvest interval (PHI) of application will be moved back such that residues have additional time to degrade. This process will be iterative, such that in subsequent years fewer pesticides will be studied, but PHI interval options studied will increase. These studies will be combined with efficacy analysis of longer PHIs to determine optimal application timing for both pest management and acceptable residues.

**f) Ozonated water to reduce pesticide residues.** Multiple studies in other crops and in stored product facilities have demonstrated that the application of ozone can degrade pesticide residues and lead to less pesticide being detected in pesticide residue analytical laboratories. Just prior to harvest in August and September 2022 we will borrow an airblast sprayer presently equipped with an ozone injection system from the WSU Center for Precision Agriculture and Automation and treat a representative block from our studies as detailed in objective e above. Following harvest and kilning we will send samples of hops from specific named varieties in objective e that were treated with the ozonated water and companion samples from the same varieties that were not treated with the ozonated water to the pesticide analytical laboratory. We will also send samples to Yakima Chief for an analysis of the brewing qualities of the hops of hops treated and not treated with this ozonated water prior to harvest to determine whether the ozone treatment has any impact on the brewing qualities of the hops. This will be a comprehensive study to quantify if the use of this ozonating technology can result in reduced pesticide residues on hops without impacting brewing quality.

**Outcomes:**

**a) Aphicide efficacy and impacts.** Short-term, we will have an indication of the relative efficacies of the various compounds applied. We will determine both the positive impact of decrease in aphid abundance and any negative impacts of reducing the abundance of beneficial arthropods. Medium-term, we may seek and achieve registrations of promising candidate compounds to expand the aphid management toolkit. Long-term, we hope to achieve sustainable aphid management under a wide range of conditions and infestation levels. Finding alternatives to the widely used neonicotinyl insecticides is imperative.

**b) Pesticide tests on other pests.** Short-term, the Walsh entomology research and Extension program strives to be nimble in response to pest issues and will respond to situations as they arise. Medium-term, as new problems continue, new objectives will be incorporated into future year proposals to the HRC, WHC, and other funding entities to complete research to fill required data needs. Long-term, we seek sustainable solutions in pest control in the ever-evolving hop IPM program amid ever-changing domestic and international regulation.

**c) Insecticide trials on caterpillars.** Short-term, we hope to identify and demonstrate soft insecticides that will control pest caterpillars without disrupting all biological control. Shifting away from pyrethroid applications is imperative. Medium-term, identifying, registering, and getting insecticides off the hop merchants’ do-not-spray lists is our objective in caterpillar control. Long-term, we seek sustainable alternatives to neonicotinyl and pyrethroid insecticides that provide effective control of pest caterpillars.

**d) Pesticide impacts on beneficial mites.** Short-term, we will gain knowledge about the impacts of registered and selected candidate insecticides on beneficial predatory mites at various concentrations. Medium-term, we can focus on additional and related chemistries to determine which other pesticides might be safe for beneficial mites while targeting pests. Also medium-term, we may seek registrations or label adjustments to reflect our findings and potentially expand the hop IPM toolkit in ways that protect beneficial mites. Long-term, our overall IPM recommendations will likely evolve to include pesticides more protective of these predators.

**e) Export viability / pesticide residues.** Short-term, we will quantify actual pesticide residues on a cohort of hop varieties given a more real-world use pattern of pesticides than protocols followed by IR-4 in developing domestic tolerances for pesticides on hops. Medium-term, we seek to have specific pesticides removed from hop merchants’ do-not-spray lists or get specific restrictions mitigated to permit uses that will result in residue levels acceptable in key export markets. Long-term, this work should permit US hop growers to apply pesticides for which we, via IR-4, have spent the time, money, and effort to obtain tolerances on US-produced hops.

**f) Ozonated water to reduce pesticide residues.** Short-term, we will determine whether the technology of applying ozonated water prior to harvest can reduce pesticide residues without impacting the brewing quality of hops. Medium-term, we will seek cost-effective ways for hop growers to adopt this ozone augmentation technology towards reducing pesticide residue on hops. Long-term, if we see adoption of this technology and it truly decreases pesticide residues, we should see a reduction in hop merchant restrictions on key pesticides in hop IPM programs.

**Extension and Outreach Activities.** Walsh and his team have a strong track record of two-way communication with hop industry leaders and stakeholders. We plan to continue our collaboration with Hop Growers of America, utilizing usahops.org as a tool for communication as well as making presentations at the American Hop Convention and meetings of HRC, Washington Hop Commission, Hop Industry Plant Protection Committee and other state and regional hop commissions and representative groups in addition to extensive one-on-one communications with growers and consultants.

**Time Frame for Objectives**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** |
| **OBJ A $9,100** |  |  |  | Establish IAREC plots | | | |  | Analyze data | | |  |
| Receive compounds and protocols from registrants | | | | Make applications per protocols or labels | | | | | |  | |
|  |  |  |  |  | Collect leaves, quantify aphids and other arthropods | | | |  | Prepare report | |
| **OBJ B $0** | Maintain two-way communication with industry to identify any emerging pest issues | | | | | | | | | | | |
|  |  | Develop & implement monitoring and/or management strategies if indicated | | | | | | | | |  |
|  |  |  |  |  |  |  |  | Analyze data | | |  |
|  |  |  |  |  |  |  |  |  |  | Prepare report | |
| **OBJ C $5,200** |  |  | Seek hop yards with large pest caterpillar numbers | | | | | | |  |  |  |
|  |  |  | Conduct efficacy trials, monitor impacts | | | | | | |  |  |
|  |  |  |  |  |  |  | Analyze data | | | Prepare report | |
| **OBJ D $6,400** | With HIPPC, develop list of candidate insecticides/miticides | | | |  |  |  |  |  |  | Refine list of chemicals deemed safe for pred. mites | |
|  |  |  | Conduct laboratory studies on predatory mite colonies | | | | Analyze results | | |
| **OBJ E $15,500** | Refine IAREC research plots as needed | | | | | Apply pesticides of concern at various rates, frequencies, and PHI intervals | | | | |  |  |
|  |  | Refine protocols with 2021 data | | | |  | Residue analysis at Pacific Analytical; data analysis at IAREC | | | |  |
|  |  |  |  |  |  |  |  |  | Prepare report | | |
| **OBJ F**  **$7,809** |  |  |  |  |  |  |  | Apply ozonated H2O | |  |  |  |
|  |  |  |  |  |  |  |  | Analyze samples and controls for residues | | |  |
|  |  |  |  |  |  |  |  | Analyze samples and controls for brewing qualities | | |  |
|  |  |  |  |  |  |  |  |  | Prepare report | | |

**Project Budget**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Expenditure | Hop Research Council Request | Commission Request (specify state) | | Total Amount Requested |
| State: WA | State: |
| Amount (cash) | Amount (cash or in-kind) |
| Salaries1 | 11,539 | 7,693 |  | 19,232 |
| Employee Benefits2 | 4,917 | 3,278 |  | 8,195 |
| Temporary or hourly workers3 | 2,340 | 1,560 |  | 3,900 |
| Travel4 | 654 | 436 |  | 1,090 |
| USA Hop Convention Registration | *Covered by companion (spider mite) proposal* | | | |
| Pesticide Residue Tests | 2,400 | 1,600 |  | 4,000 |
| Supplies5 | 2,400 | 1,600 |  | 4,000 |
| Total | 24,250 | 16,167 |  | 40,417 |

1 Hop Research Manager,Dan Groenendale at 0.10 FTE (60% HRC & 40% WHC) is $7,582.

Lab Manager, Deborah Brooks at 0.25 FTE (60% HRC & 40% WHC) is $11,650

2 Groenendale benefits @ 33.2% is $2,511; Brooks @ 45.44% is $5,294; student (below) @ 10% is $390

2 Undergraduate student summer wages (20 hrs/wk for 13 weeks @ $15/hr) is $3,900

3 Travel is for local project mileage 2,000 Miles @ $0.545/mi ($1,090).

4  Land fees $900, maintenance pesticides $1,400, and miscellaneous lab supplies $1,700

**Publications since 2021 proposal was submitted**

1. Henning, J.A., M.S. Townsend, D.H Gent, M. Wiseman, D. Walsh, D. Groenendale and A. Randazzo

Registration of High-Yielding Aroma Hop (*Humulus lupulus* L.) cultivar,‘USDA Triumph'. 2021. Plant Registrations, J. Crop Sci. Soc Am.

2. Adesanya, A. W., M. J. Beauchamp, M. D. Lavine, L. C. Lavine, Fang Zhu, & D. B. Walsh. 2021

Mechanisms and management of acaricide resistance for *Tetranychus urticae* in agroecosystems. J Pest Sci doi.org/10.1007/s10340-021-01342-x

3. O’Hearn, J. & D. Walsh. 2020. GLRaV-3 Vectored by Grape Mealybug, *Pseudococcus maritimus*

(Hemiptera: Pseudococcidae), at low population levels. J Entomol Sci doi.org/10.18474/0749-8004-56.1.106.

4. O’ Hearn, J. & D. Walsh. 2020. Effectiveness of imidacloprid, spirotetramat, and flupyradifurone to prevent

spread of GLRaV-3 by grape mealybug, *Pseudococcus maritimus* (Hemiptera: Pseudococcidae). J Plant Disease and Protection. DOI https://doi.org/10.1007/s41348-020-00359-1

5. Adesanya, A. W., T. D. Waters, M. D. Lavine, L. C. Lavine, D. B. Walsh & Fang Zhu. 2020. Multiple

insecticide resistance in onion thrips populations from Western USA. Pesticide Biochemistry and Physiology. https://doi.org/10.1016/j.pestbp.2020.104553

6. Adesanya, A. W., M. J. Beauchamp, M. D. Lavine, L. C. Lavine, Fang Zhu, & D. B. Walsh. 2020.

RNA interference of NADPH-Cytochrome P450 reductase increases susceptibilities to multiple acaricides in *Tetranychus urticae*. Pesticide Biochemistry and Physiology. https://doi.org/10.1016/j.pestbp.2020.02.016