**Project Title: Integrated Management of Mites on Hops**

**Project Summary:** The two-spotted spider mite *Tetranychus urticae* has proved to be a difficult pest to control in the hop agroecosystem. Through laboratory bioassay, field surveys, field trials, and molecular analysis we will study the efficacy of registered and candidate acaricides against pest mites. Over the past 5 years we have identified molecular markers associated with resistance to the synthetic acaricides abamectin, acequinocyl, bifenazate, bifenthrin, clofentezine, cyflumetofen, etoxazole, fenazaquin, fenpyroximate, hexythiazox, and spirodiclofen. We will collaboratively develop multiplex methods for monitoring the resistance status of mite populations infesting hop yards, focusing on acaricides for which we have found direct point mutations associated with acaricide resistance in mites collected from PNW hop yards. We have focused on abamectin, bifenazate, and hexythiazox in 2022 and we plan to move on to etoxazole and hexythiazox in 2023. In subsequent years we will move on to study fenpyroximate, pyribaden, fenazaquin, cyflumetofen, and acequinocyl. From popular request we will also continue to evaluate candidate “alternative” acaricides, several of which are commercially available natural plant extracts or oils that are exempt from tolerance and have minimal MRL issues. We have observed positive efficacy with several of these alternative pesticide treatments on mites and other pest insects. Because residue reduction has been achieved by topical “wash-off” sprays of ozonated water or hydrogen peroxide in other crops, we will test this in hops. As a subset of our SCRI funded project we are analyzing soil carbon based on hop yard floor management and grower cover crop practices. Since we are identifying hop yards in this study based on hop yard floor management practices we will follow through the subsequent 2023 growing season by quantifying the abundance of mites within each hop yard in our carbon sequestration study. A second sub objective associated with our SCRI project is an evaluation of the joint WSU-USDA extant male hop germplasm for any source of genetically based tolerance to spider mite infestation. Finally, we would like to develop a method to add automation to our mite quantification methods. We will continue to conduct our extensive outreach and engagement program and to proactively support the hop industry in research, outreach, and regulatory affairs.

**Proposed Duration:** Year 1 complete. Year 2 proposal.

**Project Leader:**

Douglas B. Walsh, Professor of Entomology

Washington State University

Irrigated Agriculture Research and Extension Center

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**Cooperators:**

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

Dan Groenendale, Field Research Director Laura Lavine, WSU Entomology

Tom Shellhammer, OSU Food Science Kayla Altendorf, USDA-ARS

Fang (Rose) Zhu, Pennsylvania State University

**Amount Requested:** $74,058 ($44,702 from HRC, $29,356 from WA Hop Commission)

**Other Funding 2023:**

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. Washington State Commission on Pesticide Registration. I will submit a request for approximately $25,000 for their funding consideration using Washington Hop Commission and Hop Research Council funds as matching funds. The $25,814 in WSCPR funds received in 2022 have been expended on partial funding of Mr. Tony Moreno’s salary for September, October, November, and December 2022. We will ask for a renewal for 2023.

4. USDA-NIFA-IR-4. Magnitude of Residue and Product Efficacy Studies 2022.

9/1/21 to 8/31/23. $58,500. These funds are paid as piece work by IR-4 at $6,500 for each MOR study. In most years we have 1 or more 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.

5. Grants in Aid. Amounts received can vary from year-to-year, but in 2022 we received $27,500 in grants in aid from various pesticide registrants to screen pesticides on hops.

**Send Funding to:**

Hollie Tuttle, Post Awards Grants Administrator

c/o WSU IAREC

24106 N. Bunn Rd., Prosser, WA 99350

Tel. 509.786.9204 Fax. 509.786.9370 Email prosser.grants@wsu.edu

**Project Title: Integrated Management of Mites on Hops**

**Statement of Problem:** This proposal addresses several aspects of priority 2 (Insect Pest Research) and incorporates priority 3 (Hop Breeding and Genomics) from the Hop Research Council’s research priorities set forth in January 2021. Within priority 2, this proposal specifically addresses priorities 1 (sustainability practices), 2 (mitigating outbreaks), 3 (MRL issues), 4 (mite control), and 6 (insecticide screening). One objective specifically addresses hop breeding in collaboration with USDA Hop Breeding program.

**Justification and Importance of Proposed Research:** Feeding by and/or contamination of hops by infestation of spider mites has resulted in millions of dollars in decreased crop value. Biological regulation of spider mites is an appreciated component of integrated pest management (IPM) in hops, but bioregulation rarely provides stand-alone control for spider mites. Acaricide application is therefore used as a risk management tool to prevent economic loss or reduce the risk of loss to an acceptable level. Market factors influence mite management decisions. When specific hop varieties are in short supply, some moderate level of mite damage is accepted by merchants. When there’s a glut of hops, mite damage can be used as a cause for rejection of hops by merchants. The work detailed in this proposal will focus on providing the information required to make recommendations for the evolving hop spider mite management program. In the studies outlined in this proposal we plan to look at traditional and alternative acaricide efficacy, fine-tune treatment thresholds, ground-truth techniques for monitoring spider mite resistance to acaricides at the landscape level, and ground-truth cost effective, robust, and rapid mechanisms for qualifying and quantifying acaricide resistance. We will try to elucidate the relationship between hop yard floor management practices and the potential for spider mite outbreaks by monitoring mite abundance in candidate hop yards. We also plan to collaborate with the USDA hop breeding program to discern if there is any genetically based tolerance to spider mites in the male germplasm located at Washington State University’s Irrigated Agriculture Research and Extension Center (IAREC). We also plan to collaborate with entomologists at Pennsylvania State University on developing a cost-effective and rapid method to qualify and quantify acaricide resistance in field-collected mites. We will use our airblast sprayer equipped with an ozone injector to quantify whether spraying hop bines near harvest with ozonated water can reduce acaricide residues. We also plan to validate a thermal imaging system for quantifying spider mite, spider mite egg, and predatory mite abundance in our mite managing system to speed our throughput while quantifying mite abundance on field-collected hop plant materials.

 Efficacy studies, resistance management, environmental inputs, variations in cultural practices, and impacts on non-target species are mainstays of any IPM program including our program in hops. Hop growers have experienced field failures of acaricides including abamectin, bifenazate, and hexythiazox due in part to development of miticide resistance in specific field populations. Over the past few seasons, we have sought to determine the mechanisms mites employ to confer this resistance. We have made substantial progress toward development of techniques that will pre-screen spider mites for the presence or absence of genes conferring resistance to conventional acaricides. We have recently hired an experienced Scientific Assistant to work on hops. Moving forward, this objective will be led by research collaborator, Dr. Fang Zhu at Pennsylvania State University Research Center. We propose to use the molecular markers we generated in our previous studies along with recently validated detection methods to develop a sensitive, rapid, cost-effective method to predict multiple acaricide resistance mutations on an economical, portable platform that will potentially be practical for in-field use, paving the way for individual growers to adopt less disruptive, more selective acaricides.

 The U.S. Hop industry has a long-standing and strong relationship of successfully registering synthetic acaricides on hops in the U.S. Unfortunately, regulatory actions involving MRLs all too often result in these acaricides landing on the major hop merchants’ do-not-spray lists. Hop growers and affiliate members of the hop industry have asked that we expand our research efforts on mite control research beyond acaricidal management, placing greater emphasis on mite management beyond registered sprays. This includes alternative acaricides like essential plant oils, augmentative release of beneficials to reduce pest mite populations, and an analysis of cultural practices that reduce or increase the likelihood of spider mite outbreaks. This proposal includes activities addressing each of these alternative management strategies.

 In 2021 there were 60,872 acres of hops harvested in the PNW. Yields averaged 1,900 pounds per acre among the 3 PNW states. Prices remained high and gross returns were calculated to be $10,868 per acre. Spider mite feeding can vary substantially among hop yards and varieties, but in extreme circumstances mite feeding can lead to complete crop failure. With super alpha varieties, mite feeding has a negative impact on the amount of alpha acids produced per acre. In our studies on Cascade we found that mite feeding must be at fairly high levels late season to cause significant damage. Unfortunately, in preliminary studies the newly released variety *cv.* ‘Triumph’ appears to be fairly susceptible to mite infestations under Yakima Valley conditions. The 2015 WSU Hop Enterprise budget listed the cost of pesticides at $750 per acre per year in a mature hop yard. Of that $750, 2 to 3 acaricide applications per year would cost ~$200 per acre. If 50,000 acres of hops were treated 2 to 3 times this would calculate out to over $10 million spent on acaricides annually. The molecular aspects of this project will develop methods to inform growers when acaricides become ineffective due to mites developing resistance. The field studies in this project will contribute to the registration of new and alternative acaricides. Evaluating the male hop germplasm for mite resistance could result in improved breeding of mite-tolerant varieties. Evaluating augmentative biological control and its efficacy may aid growers in establishing their own biocontrol programs. Decreasing residues of acaricides will likely ease export restrictions and provide for greater market access. Having a greater understanding of how hop yard floor management practices impact mite population dynamics should benefit hop growers. Finally, labor-saving automation of mite counting will ease labor demand and increase efficiency in the Walsh laboratory.

**Objectives**

1. Field test candidate compounds and recommended commercial blends of acaricides for their efficacy against spider mites. (This will be an ongoing objective)
2. Conduct field trials in grower collaborator fields with candidate alternative acaricides. This will include plant-based extracts and oils. (Year 2 of 3)
3. Develop a sensitive, rapid, and cost-effective method to predict multiple acaricide resistance on a portable platform. (Depending on progress and industry assistance 2024)
4. Screen and then bioassay selections from the male germplasm for any genetically based tolerance to mite infestation. (Year 3 of 5)
5. Complete augmentative releases of the predatory mites *Neoseiulus fallacis* and *Galendromes occidentalis*. (Year 3 of 5)
6. Determine if broadcast applications of ozonated water and hydrogen peroxide degrades acaricide residues. (Year 2 of 3)
7. Quantify the impact of hop yard floor management practices on the population and abundance of spider mites in hop yards. (Year 1 of 4)
8. Develop a multispectral/ thermal imaging method to quantify mite abundance in

association with our mite brushing mite abundance quantitation method. (Year 2 of 2)

**Procedures/Methods to Accomplish Objectives**

**a) Field tests for efficacy**. Research plots will be set up in hop yards on the WSU Prosser Irrigated Agriculture Research and Extension Center (WSU IAREC). Grower standard treatments including the insecticide/acaricide active ingredients acequinocyl, fenazaquin, and fenpyroximate will be compared to candidate compounds with some emphasis on numbered experimental compounds. Bayer Chemical Company has a new experimental acaricide. We will ask for some samples to screen on hops. We will also screen candidate alternative acaricides that have shown promise in our controlled laboratory bioassay studies. Protocols, if received from registrants, will be followed. If no protocols are received, published and/or registered label rates will be applied. All applications will be made by airblast sprayer. Ten to fifteen leaves will be collected from each plot at relevant timing after treatment. In the laboratory motile mites, mite eggs, predatory mites, and other relevant arthropods will be quantified. As the vines mature, cone samples will be taken and the spider mite and other arthropod population abundance on and in the cones will be quantified. Spider mite and other arthropod populations from treated plots will be compared with those from nontreated control plots. Spider mite abundance will be analyzed by repeated measures analysis of variance and population means of spider mites in treated plots will be compared in pairwise tests with populations in the control plots.

**b) Alternative acaricides.** A number of “alternative” plant-based extracts and oil-type products are being marketed as having acaricidal properties. Most of these products are exempt from tolerance and many target the cannabis market where, as with hops, growers have substantive issues with spider mite management. We have tested many of these alternative acaricides in controlled laboratory bioassays and in our small plot efficacy trials. Some of these products warrant commercial-scale trialing. This work will be conducted in grower collaborator hop yards. We will acquire alternative acaricides from vendors and provide them to our grower collaborators where they will be applied commercially. We have been approached by several registrants to test their candidate products. To date these include rosemary oil-based EcoRaider and Tetracurb, citric acid-based NukeEm, *Beauvaria bassiana*-based BotaniGard, organic stylet oil, neem oil, canola oil, mint oil, dill oil, and garlic oil. Plot size will be determined by the quantity of each product received. Prior to and following application we will sample 100 leaves taken at random from each of the treated blocks. We will also take samples from blocks not treated with these alternative acaricides. The mites on these leaves will be quantified under a dissecting microscope in the Hop Building in the Environmental and Agricultural Entomology Laboratory.

**c) Acaricide resistance detection.** SHERLOCK, a Cas13a-based molecular detection platform, is a highly sensitive and specific single-base detection method that can detect multiple mutations associated with acaricide resistance in hop fields (Broad Institute 2018). We will purchase recombinant Cas13a protein from NovoPro Bioscience Inc. This protein, ssRNA target 1, crRNA, and reporter (quenched fluorescent RNA) will be incubated for RPA. The SHERLOCK will be used to detect three of the most common single nucleotide polymorphism (SNP) mutations linked with acaricide resistance in PNW hop fields (G126S in the cytochrome b gene, F1538I in the voltage-gated sodium channel gene, and I1017F in the chitin synthase 1 gene) from 20 field populations of spider mites with a history of acaricide input. Populations will further be bioassayed for their resistance status to commonly used acaricides by quantifying lethal concentrations (LC10, LC50, and LC90) required to kill 10, 50, and 90% of each population via methods detailed by Piraneo et al. (2015) to validate molecular markers. The SHERLOCK fluorescence data will be calculated by crRNA ratios for SNPs. A subset of the DNA extracted will be amplified with established PCR methodology and sequenced to validate the SHERLOCK technology. For robustness, we will concurrently utilize a lab-based multiplex assay to detect acaricide resistance mechanisms. We will characterize the genetic structure of mite populations infesting regional hop yards. Individual mites will be collected from 20 representative hop yards, flash frozen, and stored at -80 C for DNA extraction by Qiagen-based kits. Individual females (~25) will be analyzed from each hop yard to assess local genetic population structure.

**d) Bioassay male germplasm for mite tolerance.** Our hop germplasm repository at WSU IAREC contains over 421 male hybrids among which some have served as the primary parentage of many variety releases and advanced selections in the repository. In 2022, the male germplasm was in a state of flux as a new yard was being established. In June and in August of 2023, four leaves from each replicate plant will be collected and bagged. TSSM will be removed from the leaves under a dissecting microscope with a fine camel-hair brush and placed on 10-cm leaf disks. Leaf disks will be imaged under a microscope to quantify trichome density. Disks will then be placed on moist cotton in petri dishes and ten gravid adult female and three adult male TSSM will be placed into each arena. The number of eggs laid will be quantified five and ten days post-placement. Also at ten days post-placement, adults will be removed and the number of eggs that have hatched and developed into larvae and protonymphs will be quantified. A cohort of 25 newly laid (translucent) eggs per replicate arena will be transferred to fresh leaf disks and held for five days and the percent hatch will be quantified. TSSM that leave the leaf arena will be sexed and quantified to adjust reproduction rates. The study will be repeated over three growing seasons to evaluate differences attributed to year and plant age. Male lines that appear to be resistant or susceptible after several years of evaluation will be entered into crossing blocks to begin the development of segregating populations.

**e) Augmentative biocontrol.** We will establish four ¼-acre plots in two separate Yakima Valley grower-cooperator hop yards with similar climatic characteristics and TSSM pressure. Into one set of plots, we will release 12,500 *N. fallacis* predatory mites twice in late spring / early summer in each project year. In the other set, we will release 5,000 *G. occidentalis* biweekly starting in late spring for a total of 5 times. Rates are based on recommendations and successes in other cropping systems and on the basis of being commercially affordable if successful. If practicable (currently under investigation), if they are commercially available, we may establish a similar program with *Stethorus punctillum,* the “Spider Mite Destroyer beetle.” In 2022, we were unable to acquire these predatory beetles.

**f) Degradation of acaricide residues.** Multiple studies in other crops and in stored product facilities have demonstrated that the application of ozone and hydrogen peroxide can degrade pesticide residues and lead to less pesticide being detected in analytical laboratories. Just prior to harvest in September 2023 we will borrow an airblast sprayer presently equipped with an ozone injection system from the Center for Precision Agriculture and Automation and treat each of 4 named varieties from our pesticide residue trials with ozonated water and hydrogen peroxide. Following harvest and kilning we will send 2 samples of each treatment to screen for specific acaricide residues and 2 that were not treated with the ozonated water or hydrogen peroxide to the pesticide analytical laboratory. Candidate acaricides for residue analysis include abamectin, bifenazate, fenazaquin, hexythiazox, and spirodiclofen due to current or pending MRL issues in the European Union. See Walsh’s other proposal, *Integrated Management of Secondary Pests on Hops 2023,* for additional details.

**g) Impact of hop yard floor management**. As part of our 2021-2015 USDA NIFA Specialty Crop Research Initiative project entitled *Enhancing Supply Chain Sustainability and Global Competitiveness for Pacific Northwest Hops* we will be surveying multiple hop yards focusing initially on the hop variety Citra. We plan to take soil samples from hop yards that have various hop yard floor management practices ranging from full tillage to the establishment of an annual grass cover crop or the establishment and maintenance of a perennial cover crop. This provides us with the opportunity to quantify how these hop yard floor management practices influence spider mite population dynamics. We will monitor these candidate hop yards by taking five 20-leaf samples from each hop yard every other week and transporting them back to the laboratory and scanning the leaves under a dissecting microscope to quantify the abundance of pest mites and aphids and the abundance of beneficial natural enemies that could contribute to the bioregulation of these pest arthropods. The number of hop yards that will be monitored is yet to be set as we will begin our initial soil surveys in October 2022.

**h) New method to quantify mite abundance.** Presently when sampling acaricide efficacy and other field studies that require the quantitation of the abundance of mites we run a specific number of hop leaves, usually 10 or 20, through a “mite brushing machine” that brushes the mites onto a round glass plate. The mites on this glass plate are visually quantified by counting the mites under a stereomicroscope. This is labor-intensive and Washington State is increasingly making it more difficult and expensive to hire temporary laborers to perform routine seasonal labor. In 2022 we will borrow a multispectral camera from the WSU Center for Precision and Automated Agricultural Systems and take videos of the circular glass plates with mites and mite eggs on them. Using a computer and some preexisting software we will determine which wavelength most accurately detects mites and mite eggs on the plate. Once this is determined we can work with a software developer to develop a software program that will “count” the mites and mite eggs on the glass plate. If this is successful, we will include a funding request in our 2024 budget for the purchase of a multispectral camera with a thermal imager. At a cost of ~$4,000, this will result in substantial savings over the current methods of quantitation.

**Outcomes**

**a) Field tests for efficacy.** Short-term, we will have an indication of the relative efficacies of the various compounds. Medium-term, we may seek and achieve registrations of promising candidate compounds to expand the mite management toolkit. Long-term, we hope to achieve sustainable mite management under a wide range of conditions and infestation levels.

**b) Alternative acaricides.** Some growers are already using these plant-based extracts and oils. Demonstration plots and sampling by our scientific staff will quantify the efficacy of these trials with alternative acaricides. Short-term, growers will have some non-anecdotal information on which to base decisions regarding use of these products. Medium-term, we will develop recommendations on including these products in the mite IPM toolkit. Long-term, our goal is the same as Objective a: sustainable mite management.

**c) Acaricide resistance detection.** Short-term, we will field-test the SHERLOCK platform on the 3 most common SNPs and get an indication of its practicality. Medium-term, we will expand its use and ascertain its applicability for growers, toward the possibility of commercial availability. A substantial part of our success will be determined by Sherlock Biosciences’ ability to pivot away from focusing almost exclusively on developing testing methods for human disease towards conducting research in other fields including agriculture.

**d) Bioassay male germplasm for mite tolerance.** Short-term, we can begin to discern whether mite tolerance is apparent in any of the male genotypes. Medium-term, we can refine these studies and focus on the pedigrees of any tolerant genotypes. Long-term, resistant genotypes identified could play a role in mite management and overall IPM in hop if mite tolerance in a male genotype is heritable and if this heritability can be quantified.

**e) Augmentative biocontrol.** This will permit us to quantify whether augmentative biocontrol of mites using *N. fallacis* and/or *G. occidentalis* is possible and economically practical.

**f) Degradation of acaricide residues**. If successful, this use of ozonated water or hydrogen peroxide may improve mite management and overcome some MRL issues with acaricides.

**g) Impact of hop yard floor management.** This study will help determine how hop yard floor management and cover cropping strategies influence mite abundance and mite population cycles among hop yards through the hop production season.

**h) New method to quantify mite abundance.** Short-term, we can find out whether this method is robust. Medium-term, this method could provide substantial labor savings (and dollar savings to our funding agencies) as hiring seasonal temporary laboratory help is becoming increasingly difficult. Long-term, this can be a component in streamlining mite and possibly other pest quantification and subsequent development of mitigation strategies.

**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$258,200** |  |  |  | Establish IAREC plots |  | Analyze data |  |
|  |  |  |  | Make applications per protocols or labels |  |
|  |  |  |  |  | Collect leaves, quantify arthropods |  | Prepare report |
|  |  |  |  |  |  | Collect cones, quantify arthropods |  |
| **OBJ B$7,200** | Finalize grower collaborator arrangements, obtain supplies of alternative acaricides, finalize protocols and plot sizes | Grower application of products |  |  |  |
|  | Obtain leaf samples, quantify mites |  |  |
|  |  |  |  | Analyze data |  |
|  |  |  |  |  |  | Prepare report |
| **OBJ C$10,408** | Finalize protocols | Incubate, detect mutations |  |  | Prepare report and next steps in collaboration with industry |
|  | Assign and train personnel | Bioassay mites for resistance status |  |
| Purchase Cas13a protein and other materials for both field- and lab-based assays | Validate molecular markers | Amplify DNA subset |
| Mite collection | Analyze data |
| **OBJ D$11,650** |  |  | String and train male hop plants | Collect leaves and field data, remove mites, establish disk arenas |  |  |
|  |  |  |  |  | Quantify trichome density, eggs, adults, sexes, and % hatch |  | Prepare report and plan for next season |
|  |  |  |  |  |  | Analyze data |
| **OBJ E****$5,900** | Determine grower cooperator(s) | Establish plots | 2x *N. fallacis* release |  |  |  |  |
| 5x *G. occidentalis* release |  |  |  |
| Determine feasibility of *S. punctillum* augmentation and conduct if practical |  |  |  |
|  |  |  |  |  |  | Analyze results | Prepare report |
| **OBJ F****$5,400** |  |  |  |  |  |  |  | Apply ozonated H20 and HsO2 |  |  |  |
|  |  |  |  |  |  |  |  | Treated and control samples to laboratory for analysis |  |
|  |  |  |  |  |  |  |  |  | Analyze data, prepare report |
| **OBJ G****$4,950** | (Due to work funded by USDA-NIFA SCRI, we will have identified growers with a range of floor management practices and will be accessing their hop yards taking soil samples for our carbon sequestration studies) |  |  |  |  |  |
|  |  |  |  |  |
|  | Analyze data |  |
|  |  |  |  | Take leaf samples every other week and quantify pest mites, aphids, beneficials |  | Prepare report |
| **OBJ H****$3,350** |  | Get camera use again |  |  |  |  |  | Vet and price cameras |
|  |  |  |  | Take videos of mites and eggs |  |  |  |  |
|  |  |  |  |  |  | Develop counting application with existing software |  |  |
|  |  |  |  |  |  |  |  | Validate automated counts against visual |  |
|  |  |  |  |  |  |  |  |  |  | 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 | $ 22,826 | $ 15,873 |  | $ 38,699 |
| Employee Benefits2 | 10,321 | 7,113 |  | 17,434 |
| Temporary or hourly workers3 | 4,680 | 3,120 |  | 7,800 |
| Travel4 | 1,875 | 1,250 |  | 3,125 |
| Attend HRC Winter & Summer Meetings | 2,000 |  |  | 2,000 |
| Cell Phone5 | 360 | 240 |  | 600 |
| Supplies6 | 2,640 | 1,760 |  | 4,400 |
|  |  |  |  |  |
| Total | $ 44,702 | $ 29,356 |  | $74,058 |

1 Hop Research ManagerDan Groenendale at 0.15 FTE (approx. 60% HRC & 40% WHC) is $11,659.

Scientific Assistant Angela Mirales at 0.15 FTE (60% HRC & 40% WHC) is $7,380.

Extension Coordinator Sally O’Neal @ 0.05 FTE (50% HRC & 50% WHC) is $3,940.

Farmer 2 Antonio Moreno @ 0.35 FTE (60% HRC & 40% WHC) is $15,721.

2 Groenendale benefits @ 36.1% is $4,203; Mirales @ 44.9% is $3,310; O’Neal @ 35.5% is $1,400; Moreno @ 49.2% is $7,741, student (below) @ 10% is $780, all divided 60% HRC and 40% WHC.

3 Undergraduate student summer wages (40 hrs/wk for 13 weeks @ $15/hr) is $7,800, divided 60% HRC and 40% WHC.

4 Travel is for local project mileage 5,000 Miles @ $0.625/mi is $3,125, divided 60% HRC and 40% WHC.

5 Partial stipend to cover a portion of Groenendale & O’Neal phones @ 425/mo, divided 60/40.

6 Land fees (2 acres @ $600) $1,200 + maintenance pesticides $3,200, divided 60% HRC and 40% WHC.