2023 Research Proposals

and

2022 Research Reports

WRRC Board of Directors - *with term expiration date, December 1, 20__*

Year	Seat	
24	1	John Clark Lynden
25	2	Andy Enfield Lynden
23	3	Mark Van Mersbergen, VP Lynden
23	4	Arturo Flores Sequim
24	5	Brad Rader Lynden
25	6	Matt Maberry Lynden
WSDA	7	Dani Gelardi, WSDA Olympia

Advisory Members
Brett Pehl – Lynden – Agronomy
Joan Yoder – Everson – Food Safety/Treasurer

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2023 Research Priorities

#1 priorities

- Develop cultivars that are summer bearing, high yielding, winter hardy, machine-harvestable, disease resistant, virus resistant and have superior processed fruit quality
- Management options for control of the Spotted Wing Drosophila – including targeting systemic action on larvae
- Mite Management – need new tools and MRLs
- Labor saving practices – ex. Pruning efficiency, public/private technology partnerships, harvester automation
- Foliar & Cane diseases – i.e. spur blight, yellow rust, cane blight, powdery mildew – *moved from #2*

#2 priorities

- Fruit rot including pre harvest, post-harvest, and/or shelf life – *moved from #1*
- Understanding soil ecology (*including biology, nutrient balance*) and soil borne pathogens and their effects on plant health and crop yields.
- Snail control – understand lifecycle and management strategies - *new*
- Cutworm, leafroller management
- Soil fumigation techniques and alternatives to control soil pathogens, nematodes, and weeds

#3 priorities

- Root weevils – *moved from #2*
- Alternative Management Systems – fruit yield per linear foot of bed – planting densities, row spacing, trellising
- Nutrient Management – Revise OSU specs, Consider: timing, varieties, appl. Techniques, calcium, nutrient balance
- Irrigation management – application techniques including pulsing
- Viruses/crumbly fruit, pollination
- Management options for control of the Brown Marmorated Stink Bug (BMSB)
- Cane Management including suppression
- Pest Management as it affects Pollinators
- Effect on BRIX by fungicide and fertility programs
- Season extension: improve viability of fresh marketing
- Maximum Residue Limits (MRL) – residue decline curves, harmonization
- Weed management – horsetail, poison hemlock, wild buckwheat, nightshade, watergrass

2023 WRRC Research Budget

PAGE	PROJECT TITLE	RESEARCHER (S)	REQUEST	DRAFT 1	Other $	Source	Approved
PLANT BREEDING			61.04%	0.00%			0.00%
5	Red Raspberry Breeding, Genetics and Clone Evaluation	Hoashi-Erhardt	$73,965		$253,967	NWCSFR	
16	Coordinated Regional on-farm Trials	NWBF - Walters	$5,928		$1,200	in-kind	
21	Red Raspberry Cultivar Development	Dossett	$10,000		$236,000	Ag Canada	
28	Cooperative raspberry testing and cultivar development	Hardigan	$6,000				
-	WRRC Land and Management fees		$25,000				
ENTOMOLOGY			21.16%	0.00%			0.00%
44	Two-Spotted Spider Mites in Red Raspberries	Schreiber	$12,495		$17,955	WSCPR	
55	Developing an Insect IPM Program	Nottingham	$18,575		$15,767	WSCPR	
59	Management of Slug and Snails	Schreiber	$10,833		$14,500	WSCPR	
WEEDS			6.31%	0.00%			0.00%
63	New Technology, Products for Raspberry Weed Management	Benedict/Schreiber	$12,495		$17,955	WSCPR	
PHYSIOLOGY			6.95%	0.00%			0.00%
69	Calcium accumulation and increasing fruit uptake	DeVetter	$13,774		$165,202	NWCSFR	
PATHOLOGY/VIROLOGY			4.54%	3.25%			0.00%
80	Virus Testing of PNW raspberry breeding programs	Hardigan	$6,000				
85	Control of Cane Blight in Red Raspberries	Schreiber/Jones	Final				
89	Extending the lifetime of plantings with novel post-plant nematicides	Walters	-	$6,445	2022 budget		
93	Characterization of Botrytis on red raspberries	Stockwell/DeLong	$3,000		extension	WSCPR	
SOILS			#REF!				#REF!
99	Application of Soil health concepts to red raspberry production	Zasada	Final				
	Total Production Research		**$198,065**	**$6,445**	**$722,546**		**$0**
	Research Related	WRRC expenses	$3,500	$3,500			$3,500
	Small Fruit Center fee		$2,500	$2,500			$2,500
	TOTAL		**$204,065**	**$12,445**			**$6,000**
	2023 Research Budget		$195,000	$182,555	report only	applied	
				$6,445			
				$189,000			

PLANT BREEDING

Project: 13C-3755-5641
TITLE: Red Raspberry Breeding Genetics and Clone Evaluation
PROJECT LEADER: Wendy Hoashi-Erhardt, Program Lead
WSU Puyallup Research and Extension Center
Reporting Period: 2022

OBJECTIVES:
Develop summer fruiting red raspberry cultivars adapted to machine harvesting with improved yields and fruit quality, and resistance to root rot and raspberry.

Accomplishments:

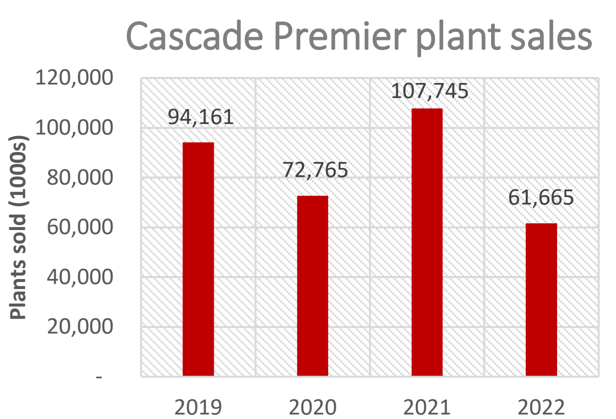


Figure 1. Sales of Cascade Premier in the Pacific Northwest 2019-2022

Cultivar and prospective cultivars.
'Cascade Premier' was released in 2017. It is exclusively licensed to Northwest Plant Company and plant sales are outlined in Figure 1. Cascade Premier is a cultivar that machine picks well, with demonstrated tolerance to root rot. It is a productive, early season cultivar that gives large fruit with good firmness and flavor. It has similar pH, titratable acidity, and total phenolics content similar to Willamette fruit, and anthocyanins levels similar to Meeker. The weather conditions in 2022 gave rise to intense root rot pressure, and 'Cascade Premier' along with other cultivars, was observed with some symptoms of the disease in some fields.

WSU 2188 is a very promising advanced selection and is being tested at several regional sites in grower trial. Overall, WSU 2188 has large fruit, good firmness, and good flavor. Its season is temporal with Meeker. The WSU plant breeding program successfully leveraged WRRC funding to procure funding from the NW Center for Small Fruit Research for a 3-year research project to evaluate Cascade Premier and WSU 2188 for IQF performance. The program expects to gather data over the next season and recommend release to the cultivar licensing committee in 2023.

WSU 2029 is a floricane-fruiting red raspberry cultivar with good yields of medium large, firm, bright red fruit with good flavor. This cultivar is notable for its very late fruiting season and its high tolerance to *Phytophthora rubi*. (Man in 't Veld, 2007) in field trials. 'WSU 2029' should be adapted to raspberry growing regions in the Pacific Northwest and is well suited to fresh production. The program is working to release WSU 2029 under a nonexclusive license.

WSU 1607 (Cascade Gem) was licensed exclusively in Europe with Meiosis, with no release in North America. Over 400,000 plants of Cascade Gem were planted for long cane production in 2022, bringing significant royalty income back into the plant breeding program. This is a success story for overseas technology transfer that doesn't compete with Washington's processed red raspberry industry but brings in royalty income to support the breeding program.

Crosses/selections.
New crosses were performed in 2022 between parents with traits of excellent machine-harvested yield, berry firmness, and root rot tolerance. Several crosses didn't reach maturity because of the unexpectedly high Pseudomonas blight and root rot that These seeds are being germinated to form the new seedling field to be planted in 2022.

There are 3 seedling fields being maintained for evaluation, indicated in the table below.

Establish-ment year	Number of seedlings	Activities in 2022
2020	~3800	Many seedlings died due to problems related to establishing and irrigating in 2020 and 2021 because of labor issues during COVID, heat dome and irrigation.
2021	~ 100	Program dealt with deferred maintenance and technical staff turnover at the farm.
2022	~500	Program installed new technician at the end of August. Alex Gregory was able to establish a small seedling field that fall.

Crosses made in 2019 were planted at the WSU Goss Farm in 2020 and 53 selections were made in summer 2022. The crosses emphasized parents that are machine harvestable and root rot resistant. Of the current year selections, 16% were derived from WSU 2425, and 13% each from WSU 2069, WSU 1447, and WSU 1480. Tips of these selections were collected in Fall 2022 for establishment in tissue culture and propagation for the next stage of testing in the machine harvesting trial. The new selections were also dug for maintenance as stock plants and virus testing.

Machine Harvesting Trials. A new machine harvesting trial was planted in 2022 at Randy Honcoop's farm. Two other machine-harvesting trials were maintained and evaluated for yield and fruit quality in 2022 as indicated in the table below.

Establish-ment year	Number of selections	Achievements
2019	47 and 3 cultivars	Maintained and harvested; evaluated selections for the second season for fruit quality and yield to drive advancement and discard decisions. Planting was removed at the end of 2022.
2021	84 and 3 cultivars	Planting was produced to generate primocane growth in advance of the first cropping year in 2023.
2022	75 WSU + 14 ORUS selections, 3 cultivars	Prepared, planted and maintained. This planting will be harvest for yield in 2024 and 2025.

The 2019 MH trial was evaluated in 2021 and 2022. Several selections stood out for outstanding qualities of plant durability, yield, or fruit quality. WSU 2632, had After two years of observational yield and fruit quality evaluation in the 2019 MH trial, the following selections will be advancing for further evaluations for yield and fruit quality:

- WSU 2516. This selection had nearly double the yield of 'Meeker'. In tests in Oregon, had excellent low drip loss from frozen and was highly rated for frozen flavor. The fruit is large, but a bit too open and not as firm as preferred. This selection will be prioritized as a parent.

- WSU 2610. High yield, early, large, firm, light color, machines well, good integrity. This selection had excellent plant durability and fruit quality, but is too light colored. It is destined for fresh trial.
- WSU 2632. Good yield but comparable with ‘Meeker’. WSU 2632 is early season, medium size, good firmness, machines well, pretty good. This selection will be advanced for selection trial.

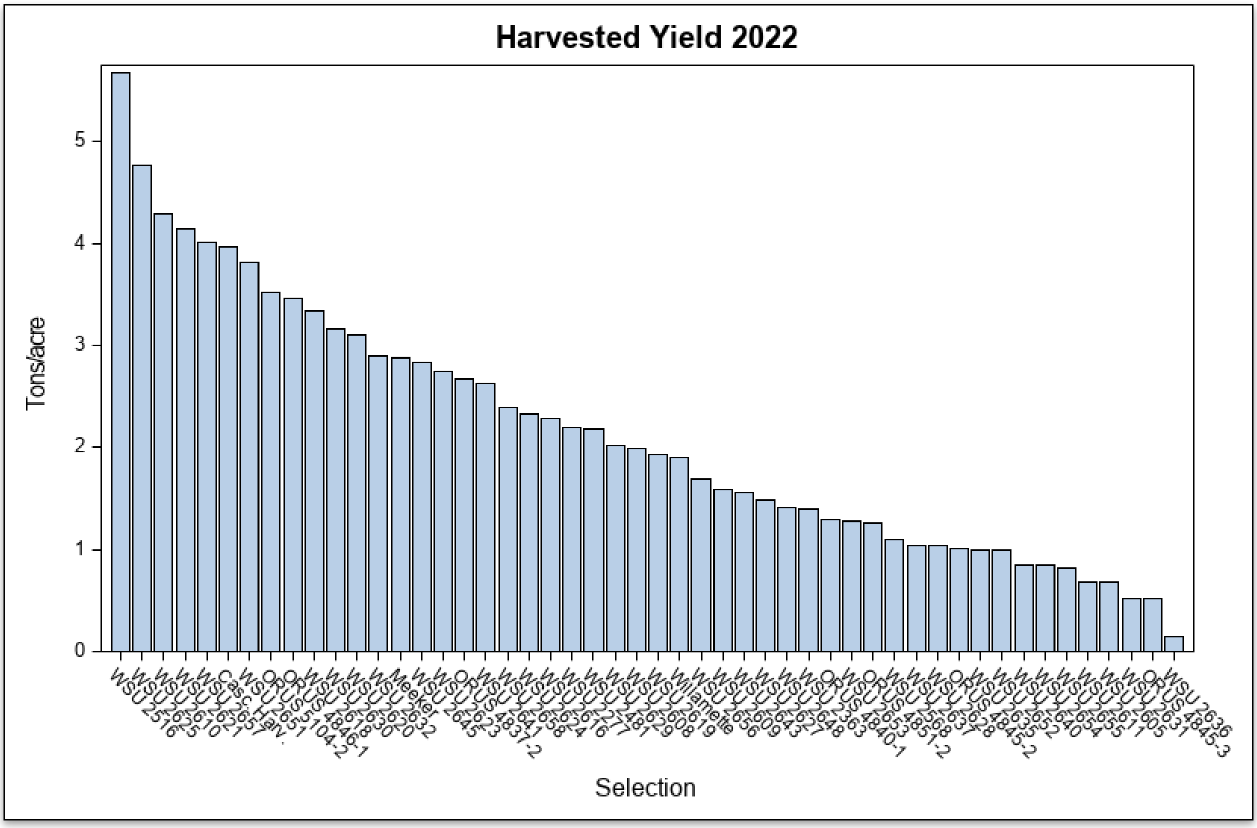


Fig. 2. Yield in 2022 of selections in the machine harvesting trial established in 2019 and harvested in 2021 and 2022. Yield is expressed as tons per acre assuming 1980 plants per acre.

Grower Trials.
Five advanced selections that are currently in grower trial on multiple sites in Washington. Each of these selections show a lot of promise for root rot tolerance, machine harvesting, yield, and fruit quality:

Selection	Grower Trial Stage	Description
WSU 2130	4 grower sites	Very high yielding in Puyallup, North Willamette, and Enfields over two harvest seasons. At heavy root rot site, saw some affect on growth in 2022. Early ripening season, similar to Willamette, with firm, attractive, conic, medium sized fruit. Good winter hardiness.
WSU 2068	3 grower sites	High yielding, early season selection with large berries with good firmness. Tolerant to root rot, appears to have better field

		tolerance than 2069. Very good winter hardiness. Early fruiting, full canopy, good flavor.
WSU 2069	3 grower sites	High yielding, early season selection, large berries with good firmness. Very good winter hardiness, and early. Flavor not quite as good as 2068. Canes white with cane Botrytis at one location. Root rot tolerance also not quite up to the level of 2068.
WSU 2088	4 grower sites	High yields at WSU Puyallup; high yield, and excellent firmness in nonreplicated grower trial compared with Wakefield. Overall dark color berries of medium size. Late season selection.
WSU 2087	3 grower sites	Two year yields similar to Wakefield. Berries are rich dark red, very firm, hefty thick walled, and large. Very good yields in the mid-late season. Root rot tolerance has been excellent in intense disease year of 2022.

Yield and Fruit Quality Evaluations (selection trials). The program did not establish plantings in 2019 or 2020, so no harvest or fruit quality data was collected. From 2021 on, the program is conducting replicated yield trials in near Lynden with grower cooperators. Two plantings are currently underway but not scheduled to be harvested this past year.

Establish-ment year	Number of selections	Tasks and plans
2021	18 selections; 3 cultivars	Established in 2021. This planting will be evaluated for replicated yield and fruit quality in 2023 and 2024.
2022	8 selections, 3 cultivars	Established in 2022. This planting will be evaluated for replicated yield and fruit quality in 2024 and 2025.

In 2023, the Small Fruit Plant Breeding program will be conducting replicated yield and fruit quality evaluations in collaborations with Lisa DeVetter's small fruit horticulture program for the trials in Whatcom Co. This is expected to be a productive ongoing collaborative activity. It also establishes a valuable "showcase" of advanced WSU germplasm to increase visibility to the raspberry industry and for a prospective faculty plant breeder as the hiring process progresses.

Root rot evaluations. The Goss Farm is known for high levels of root rot and is an ideal field to screen selections for their tolerance to *Phytophthora* root rot. Three plantings are currently being maintained and evaluated at WSU Puyallup as indicated by the table below. Each planting contains single-plant plots in four replicates. Results are included in tables 1-3.

Establish-ment year	Number of selections	Tasks and highlights
2019	27, 4 cvs	Maintained; evaluated selections for the final time. The planting was severely impacted by root rot.
2020	20, 4 cvs	Maintained; evaluated selections for establishment in 2021 and in 2022 for root rot response. The planting was severely impacted by Pseudomonas blight and by root rot in 2022; most of the planting died from the impact of these two diseases.

2021	21, 3 cvs	Maintained; evaluated selections for 1st time for establishment. Established this root rot planting for first evaluation in 2022.
2022	21 WSU, 23 ORUS, 3 BC, 2 cvs	Established this root rot planting for first evaluation in 2023.

Publications/Presentations

Raspberry and Strawberry Breeding Update, Small Fruit Conference, 1 Dec 2021.

Tables

Table 1. Establishment of WSU selections and standard cultivars planted in 2019 in a root rot infested area at WSU Puyallup.

Selection	Establishment Rating 2020[z]	Rating 2021[y]		Rating 2022[z]
ORUS 4545-2	3.5	4.8	a	4.8
Twilight	2.8	4.3	ab	4.8
ORUS 3021-2	3.8	3.3	ab	3.0
ORUS 3381-3	2.5	3.8	ab	3.0
ORUS 4412-2	2.5	2.8	ab	3.0
ORUS 5094-1	2.8	3.5	ab	2.3
ORUS 5106-3	0.8	2.0	ab	1.5
ORUS 4222-1	1.8	1.5	ab	1.3
ORUS 4535-1	1.0	2.0	ab	1.3
ORUS 4959-1	2.3	1.5	ab	1.3
Willamette	3.3	3.3	ab	1.3
ORUS 5094-2	1.3	2.3	ab	1.0
ORUS 4965-3	1.0	1.3	ab	0.8
WSU 2162	2.8	3.0	ab	0.8
ORUS 3032-3	1.0	1.0	ab	0.5
WSU 2277	1.3	1.8	ab	0.5
WSU 2605	2.3	2.0	ab	0.5
ORUS 4487-1	2.0	2.0	ab	0.3
ORUS 5106-1	1.5	2.8	ab	0.3
Cascade Harvest	1.5	1.8	ab	0.0
Meeker	2.3	3.0	ab	0.0
ORUS 4693-2	0.8	1.0	ab	0.0
ORUS 4716-1	2.3	2.0	ab	0.0
ORUS 4858-2	1.8	0.8	ab	0.0
ORUS 4870-2	1.8	2.0	ab	0.0
ORUS 4974-1	1.8	0.0	b	0.0
ORUS 4985-1	1.5	1.0	ab	0.0
ORUS 5104-2	2.8	2.0	ab	0.0

WSU 2363	1.5	0.5	ab	0.0
WSU 2481	1.0	0.0	b	0.0
WSU 2516	2.3	2.5	ab	0.0

^{z}Rating was an a scale 0-5, where 0 = non established/dead plant; 5= vigorous, thriving

^{y}Ratings within a column followed by the same letter are not significantly different at P<0.05.

*Note: weather conditions in 2022 led to very intense root rot disease pressure and die-off of many selections that had previously shown some degree of tolerance.

**Note: Selections in italics are blackberries or black raspberries.

Table 2. Root rot response in 2022 of WSU selections and standard cultivars planted in 2020 in a root rot infested area at WSU Puyallup.

	Replicated	
Selection	Rating 2021^z	Rating 2022
WSU 2577	2.75	2.25
Cascade Harvest	4.25	1.5
WSU 2376	3.25	1.333333333
WSU 2377	3.5	1.25
Willamette	4.25	1
WSU 2425	3.5	1
WSU 2001	3.5	0.75
WSU 2088	3	0.75
WSU 2277	1.75	0.75
Meeker	3.75	0.5
WSU 1962	4	0.5
WSU 2348	3.75	0.5
	Non-replicated	
WSU 2557	5.0	5.0
WSU 2472	4.0	4.0
WSU 2561	4.0	3.0
WSU 2442	5.0	2.3
WSU 2571	2.7	1.3
WSU 2481	4.5	1.0
WSU 2482	3.5	1.0
WSU 2082	3.3	0.7
WSU 2575	2.3	0.3

^{z}Rating was an a scale 0-5, where 0 = non established/dead plant; 5= vigorous, thriving

2023 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

Continuing Project Proposal Proposed Duration: 1 year
PROJECT: 13C-3755-5641
TITLE: Red Raspberry Breeding, Genetics and Clone Evaluation
CURRENT YEAR: 2022

PI:	Wendy Hoashi-Erhardt	**Co-PI:**	Lisa Wasko DeVetter
Organization:	WSU Puyallup	**Organization:**	WSU Mount Vernon
Title:	Program Lead	**Title:**	Associate Professor
Phone:	253.445.4641	**Phone:**	360-848-6124
Address:	2606 W Pioneer Ave.	**Address:**	16650 State Route 536
City/State/Zip:	Puyallup, WA 98371	**City/State/Zip:**	Mount Vernon, WA 98221

Cooperators: Northwest Berry Foundation; Michael Hardigan, Mary Peterson, and Dimitre Mollov, USDA-ARS; Scott Lukas and Pat Jones, OSU; Michael Dossett, BC Berry Council; Tom Walters, Walters Ag Research; Julie Enfield and Lisa Jones, Northwest Plant; Randy Honcoop, former grower; regional growers.

Year initiated: 1987 **Current year:** 2022 **Terminating Year:** continuing

Project Request: $ 73,965

Other funding sources:
Agency Name: Northwest Center for Small Fruits Research
Amt. Awarded: $32,299
Notes: Funds will be used to provide partial technical support for the program.

Agency Name: Northwest Center for Small Fruits Research
Amt. Awarded: $86,432
Notes: Funds are to evaluate two new red raspberry cultivars, 'Cascade Premier' and WSU 2188, for Individually Quick Frozen (IQF) processing quality, yield, pest tolerance, and winter hardiness.

Agency Name: Northwest Center for Small Fruits Research
Amt. Awarded: $135,236
Notes: Funds are to develop genomic prediction models as an important first step toward the application of genomic selection for tolerance to root lesion nematode in red raspberry.

Description: The program will develop new red raspberry cultivars for use by commercial growers in the Pacific Northwest, with emphasis on new cultivars with high yield, machine harvestability, root rot tolerance, nematode tolerance, and raspberry bushy dwarf virus (RBDV) resistance with superior processed fruit quality. Using traditional breeding methods, the program will produce seedling populations, make selections from the populations, and evaluate the selections through multiple stages of performance assessments for yield, plant horticultural characteristics, disease/pest tolerance, and fruit quality, including firmness, color, flavor, and size. Selections will be evaluated for adaptation to machine harvestability by planting selections with cooperating growers. Promising selections will be propagated for grower trials, leveraging grower trial data toward cultivar release decisions.

Justification and Background: Washington's growers are leaders in the production of the processed red raspberry in the U.S., and they compete closely with California's industry as well as with international players. To maintain and enhance their competitiveness in this valuable specialty market, Washington's growers need new cultivars emerging from the WSU breeding program. The timeliness of this project lies in three main factors: 1) WSU is one of 3 US public programs breeding floricane-fruiting red raspberry; 2) the cooperation between growers, processors, and researchers is strong; and 3) Washington growers critically need a competitive edge.

New cultivars emerge through an annual cycle of germplasm collection and maintenance, new crosses, new selections from previously planted seedlings, successful propagation, and extensive selection evaluations for machine harvestability, yield, harvest season, fruit quality, and response to disease and abiotic factors. These evaluations occur in research-scale plots at WSU-PREC and other research facilities and commercial-scale plantings across the region. The program proposes to continue the annual plant breeding activities that form the basis of successful plant breeding, as well as intensive evaluations of elite red raspberry selections to accelerate their release as cultivars for Washington's red raspberry industry.

WSU's small fruit breeding program has made significant gains incorporating machine harvestability, excellent fruit quality, and root rot tolerance into its elite germplasm in the last 15 years. Additionally, the program successfully wins new funding for research valuable to WRRC growers. Two examples are 1) evaluating two new WSU genotypes for IQF quality and 2) examining the potential for genomic selection for root lesion nematode resistance.

WSU's plant breeding program is at a critical period in its tenure as the preeminent processing red raspberry breeding program in the United States. The BC, Oregon, and WSU breeders work cooperatively to test each other's germplasm and coordinate evaluations. To attract an excellent new faculty breeder to this program, the core germplasm collections need to be preserved, and the active annual processes of traditional breeding strengthened.

Relationship to WRRC Research Priorities: This project addresses a first-tier priority of the WRRC: Develop cultivars that are summer bearing, high yielding, winter hardy, machine-harvestable, disease resistant, virus resistant and have superior processed fruit quality.

Objective: Achieve the next stage of development of new summer-fruiting red raspberry cultivars with improved yields and fruit quality, and resistance to root rot and raspberry bushy dwarf virus; conduct on-farm and disease evaluations to accelerate the release of advanced selections adapted to machine harvesting.

Anticipated Benefits and Information Transfer: The program will continue annual plant breeding activities that lead to genetic gain and the potential for elite red raspberry selections to become cultivars. Additionally, the program will preserve germplasm, develop cooperative protocols with DeVetter's WSU Small Fruit Horticulture program, further transition plant breeding activities to Whatcom County, and leverage WSU germplasm for basic genomic research. These objectives also increase the value of collaborative relationships and active projects between regional breeders, horticultural researchers, extension specialists, and nursery and grower cooperators. Results will be transferred through regular meetings with the WRRC, field days, Small Fruit Update and Whatcom Ag Monthly newsletters, and grower conferences.

Procedures

1. Crosses (0^{th} stage). PREC. Cross parents likely to produce progeny with excellent traits. Status: Planned for Spring 2023.
2. Seedlings (1st stage). PREC. Germinate seeds from crosses, plant, grow for 2 years and identify excellent individuals (selections) to enter cultivar development pipeline. Status: Seedlings will be established in 2023 with Brad Rader with separate WRRC funds.
3. Observational Machine harvest (MH) trial (2nd stage). Lynden. New selections are propagated and tested for machine harvestability, yield, and fruit quality. Status: 2021 MH trial will be evaluated 2023; 2022 MH trial maintained for eval next year; 2023 MH trials will be established with Brad Rader under separate WRRC funding.
4. Replicated Yield Trial (3rd stage). Lynden. Selections that have performed well in the observational MH trial are evaluated in replicated plots for yield and fruit quality. Status: 2021 rep trial will be evaluated for yield and fruit quality; 2022 rep trial will be maintained for evaluation next year; 2023 planting to be planted in spring with Brad Rader under separate WRRC funding.
5. Root rot trial. PREC. Root rot response is evaluated in comparison with standard cultivars for 3 years. Status: Root rot plots planted in 2021 and 2022 will be maintained and evaluated for tolerance in 2023. A new planting will go in.
6. Regional replicated trials (Adv stage). Dossett/BC, Hardigan/OR. Selections from 3rd Stage are evaluated in replicated plots for yield and fruit quality across growing environments. WRRC funding supports propagation and transport of WSU material, but all costs of planting and evaluation are borne by other programs.
7. Grower Trials (Adv stage). Walters, Pond/NBF. Three to four elite selections will be propagated, tested for virus, sent to the nursery, then tested by growers to assess for yield, fruit quality, and traits important to commercial production, like establishment, water use, disease susceptibility, and winter hardiness. WRRC supports propagation, virus testing, and coordination required for selections to get to nurseries and growers.
8. Propagation (supporting). PREC. Generate multiple plants of single, genetically unique selections through tissue culture and greenhouse methods for all the plantings listed above. Year-round management of laboratory, personnel, greenhouse, and supplies.
9. Germplasm (supporting). PREC. Maintain and preserve core and experimental germplasm. Key for cultivar integrity and tracing. Also crucial for introgressing important traits from diverse Rubus germplasm. Year-round management of germplasm in tissue culture, screenhouse stock plants, field stock plants.
10. Virus testing (supporting). PREC, Mollov, Lake USDA. Propagate, initiate testing, and maintain records on selections and propagules and their virus status for timely propagation for grower trial. Year-round management of records and selection propagation status, collaboration with virologist at USDA.

Budget:

Budget		2023-2024
Salaries - 00		$ 20,003
Plant Technician (0.50 FTE)	$ 20,003	
Time-slip Wages - 01		$ 21,000
Goods/Services - 03		$ 21,500
Machine harvest trials, including rep. yld trial	$ 15,000	
Land use fees	$ 500	
Supplies	$ 6,000	
Travel - 04		$ 1,625
Benefits - 07		$ 9,837
Total Direct Costs		**$ 73,965**

Budget Justification

Salaries and Wages:
Scientific Assistant. Scientific assistant Gregory will prepare and till fields, maintain equipment, design and plant plots, scout and treat pest problems, prune, trellis, do other plot maintenance, and supervise temporary employees. This equates to 0.37 FTE ($20,003).
Non-student temporary worker. A temporary worker will conduct tissue culture and greenhouse propagation, at a wage of $20/hr for 12 hrs/week for 50 weeks ($12,000)
Student and temporary worker. Seasonal workers will harvest fruit, collect data under supervision of PIs, maintain plots, and do field work. This includes timeslip help to collect data at grower field in MH trial. This equates to 600 hours at $15/hr ($9,000).

Benefits. Scientific Assistant benefits are $7,695 for 0.37 FTE. Temporary employee benefits amount to $2,142.

Goods and Services.
Machine harvesting (MH) trials**.** Cooperating grower is paid as a service contractor to maintain MH trial, harvest plots, and communicate with researcher. Total is $15,000.
Land use fees. WSU farm services fees for seedling, selection, and germplasm plantings amount to 5 acres at $100/acre ($5,000).
Supplies. Crop protection products, fertilizers, potting media and containers, irrigation equipment, greenhouse electricity, harvest equipment and consumables, and laboratory reagents and consumables will be needed to conduct this work ($6,000).

Travel. Travel for the project, including to visit trial plots, meet with collaborators, and present results are estimated to be 6 trips between Puyallup and Lynden (round trip and local = 300 miles x $.625/mile x 6 trips - $1,125) in one year, and 5 nights in a hotel in Lynden (5 x $100 = $500).

Current Support

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of time committed	Title of Project
Hoashi-Erhardt	Northwest Center for Small Fruit Research	$33,000	2021-2022	10%	Small Fruit Breeding in the Pacific NW
Walters, TW and Hoashi-Erhardt	Northwest Center for Small Fruit Research	$21,000	2020-2023	3%	Trials of Advanced Raspberry selections to evaluate suitability for IQF processing and to promote adoption
Hoashi-Erhardt, DeVetter	Washington Red Raspberry Commission	$93,169	2021-2022	20%	Red Raspberry Breeding, Genetics and Clone Evaluation
Hoashi-Erhardt	Oregon Strawberry Commission	$6,000	2021-2021	2%	Genetic Improvement of Strawberry
Hoashi-Erhardt, Zasada, Hardigan, Dossett	Northwest Center for Small Fruit Research	$135,236	2021-2024	5%	Genomic Prediction for Quantitative Resistance to Root Lesion Nematode in Raspberry
Hoashi-Erhardt, Luby, Watson, Winfree, Pond	Northwest Center for Small Fruit Research	$46,795	2022-2024	3%	

Pending Support

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of time committe d	Title of Project

Washington Red Raspberry Commission
Progress Report for 2022

Project No: Walters 2022 Contract #8

Title: Coordinated Regional on-farm Trials of Advanced Raspberry Selections and Newly Released Cultivars

Personnel: PI: Tom Walters, Walters Ag Research
Co PI's: Julie Pond, Northwest Berry Foundation; Wendy Hoashi Erhardt, WSU; Michael Hardigan, USDA-ARS, Julie Enfield, Northwest Plant

Reporting Period: Jan 1-Dec 31 2022

Accomplishments:

- Final evaluations of 2017 and 2018 on-farm trials
- Third year (full crop) evaluations of three spring 2020-planted trials
- Second year (baby crop) evaluations of fall 2020-planted trial and two spring 2021-planted trials

Results:

Cascade Premier Trialed 1 location 2020. Good fruit quality at harvest, a few greens on harvester. Very large fruit in flat. Large receptacle opening makes it seem softer than it is.

WSU 2188 Trialed 2 locations 2020, 2 locations 2021. Large, droopy-looking plants, long leaves. Good winter hardiness, excellent budbreak. Bloom time sim Meeker. Baby crops had many broken laterals at all trials, but older plants fared better. Enough of a problem to impact yield. Very dense canopy. Susceptible to cane Botrytis, similar to Cascade Premier. Fruit uniform, looks excellent in flat, goes through IQF without crumble, good color and quality. Likely release 2022-2023.

WSU 2068 Trialed one location 2020. Very good winter hardiness. Early fruiting, full canopy, firm, good yield, good flavor.

WSU 2069 Trialed one location 2020. Also very good winter hardiness, and early, like WSU 2068. Flavor not quite as good as 2068. Canes white with cane Botrytis at one location. Root rot tolerance also not quite up to the level of 2068. In the 2020 trial, more ripe fruit than 2068, long harvest season. Larger drupelets than 2068, a bit rough-looking. A lot of fruit on the ground. Early maturing, perhaps not harvested early enough. Fruit on belt crumbly, not great at this location.

WSU 2087 Trialed one location 2020, one location 2021.

WSU 2088 Trialed 4 locations 2020. Many fruits per lateral, long fruiting season. Short-statured, smaller than 2130. Fruit seems to be good quality in the first season. Fruit on harvester dusky, a bit purplish. Excellent yields at one trial, but did not stand out so much at the others.

WSU 2130 Trialed 4 locations 2020. Good winter hardiness. Red laterals. Good amount of attractive, conic fruit across the canopy, looked promising in June, but hard hit by heat damage late that month. Small plant without much fruit at a heavy root rot site. Compact plant, fruit outside canopy. Fruit uniform, conic, dark, attractive, possibly a bit soft. Heavy yields in at least two of the trials.Lots of fruit on the ground-early maturing?

ORUS 4607-2 Trialed 1 location 2020. Large, conic fruit, many ripening same time. Very few spines. Canes not many, but large and thick. Tops of arcs bare, although other varieties in field are not. Possible cold injury.

Publications: 2021 results were featured in the Small Fruit Update newsletter; 2022 results will also be in a forthcoming edition of the Update.

2023 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

Project Proposal **Proposed Duration:** 3 years

Project Title: On-farm Trials of Advanced Raspberry Selections

PI:
Tom Walters
Owner, Walters Ag Research
360-420-2776
waltersagresearch@frontier.com
2117 Meadows Ln
Anacortes WA 98221

Co PIs
Julie Pond, Northwest Berry Foundation, Portland OR
Michael Hardigan – USDA-ARS-HCRU, Corvallis, OR
Wendy Hoashi-Erhardt – Washington State University, Puyallup, WA
Julie Enfield – Northwest Plant Company, Lynden, WA

Cooperators
Eric Gerbrandt, Sky Blue Horticulture, Ltd., Chilliwack, B.C.

Year Initiated 2022 Current Year 2023 Terminating Year 2023

Total Project Request: 2023: $5,928

Other funding sources:

In-kind contributions: $1200 (estimated 800 plants for trials in 2023. Plant value is $2.50/plant, less $1/plant paid by this grant)

Description

Maintain an ongoing network of regional on-farm grower trials for evaluating red raspberry advanced selections and newly released cultivars from the WSU breeding program, the USDA-ARS/OSU breeding program, and the British Columbia raspberry breeding program combining public and private resources to accelerate the commercialization of our genetic resources. Over the first years of this project the grower/cooperator network has been developed; trials have been established; the infrastructure has been created and implemented for collecting, recording, and disseminating trial information.

This year's proposed work will continue evaluation of elite selections from the WSU and USDA raspberry breeding programs in Whatcom county growers' fields. The program will evaluate trials established 2020 and 2021, including 4 trials with 50-150 plants each of 3-6 selections in each trial, as well as two 2-4A trials of WSU 2188 for IQF evaluation. We will coordinate trial management with growers, collect trial data directly and through the grower-cooperators, and disseminate trial findings to the industry at meetings, through the Small Fruit Newsletter and elsewhere.

Justification and Background
We are blessed to have three publicly funded raspberry breeding programs in our region, with one of them based in Washington State. All of these programs develop and trial advanced selections, and growers can see these at field days. However, growers need to know more than what they can learn from small-plot trials before committing to a variety, so adoption of new varieties is usually slow. On-farm trials of advanced selections are needed to see plant and fruit performance firsthand in growers' fields, and to increase awareness of the best selections among growers.

The WSU Breeding program is in transition with the retirement of Dr. Pat Moore. There are advanced selections from this program to be evaluated, and Dr. Moore's successor will be able to get off to a faster start if these evaluations are already underway. Along with Wendy Hoashi-Erhandt's management of the breeding program transition, these trials help prepare the new WSU plant breeder for success.

We plan to address this issue because price pressures on raspberry growers are severe, and there is more need than ever for varieties that yield well and consistently produce high-grade fruit. We believe we are well-positioned to do this work, because we have broad experience in canebery production and pest management, along with local expertise in Whatcom county and BC, and a well-developed, well-read vehicle for information dissemination (the Small Fruit Newsletter). We will coordinate the Washington Trials with trials in Oregon and with Eric Gerbrandt's trials with the BC Berry Council.

For the last eight years the Northwest Berry Foundation has been organizing a commodity commission funded pilot program for on-farm evaluations of caneberry selections and cultivars. In the past year, the Foundation improved regional coordination in NW Washington and reduced travel costs by adding Tom Walters as supervisor for these trials. NBF did not add any new caneberry cultivar trials in 2019, using the year to evaluate existing trials and to improve coordination and procedures.

This project is directly related to and in communication with Dr. Eric Gerbrant's cultivar evaluation projects in British Columbia, and to NBF's ongoing caneberry and strawberry evaluations in Oregon. Together, these projects provide a cohesive system for evaluating advanced selections, compiling data on a common system and disseminating the information to the grower community.

Relationship to WRRC Research Priority(s): Priority 1 Develop cultivars that are summer bearing, high yielding, winter hardy, machine-harvestable, disease resistant, virus resistant and have superior processed fruit quality

Objectives:
In 2022, we will:

- Make third year (full crop) evaluations on the three spring-planted 2020 trials.
- Make second year (baby crop) evaluations on the fall-planted 2020 trial, as well as spring-planted trials of WSU 2188 (two plantings, 2-4 A each), and WSU 2087
- Develop list of selections to be included in onfarm trials in future years and coordinate with Northwest Plant Co for their propagation.
- Disseminate coordinated information from BC, WA and OR trials to growers

Procedures:

We will make overwintering and third harvest evaluations of the three spring-planted 2020 trials, including WSU selections 2068, 2069, 2088, 2130 and USDA selection ORUS 4607-2. These will focus on overwintering, vigor, fruit quality, root rot resistance and response to other diseases and pests.

Selection WSU 2087 is in one of the 2020 smaller-scale row trials and in two spring-planted 2021 trials. These will be evaluated as well.

One grower has prepared for field-scale (4A) evaluation of WSU 2188, which was planted Spring 2021. The first year (baby) crop was evaluated in 2022, including preliminary IQF evaluation. Full crop evaluations will take place in 2023. These evaluations will be critical to the decision whether to release this selection.

A new trial with WSU and BC selections will be planted 2023.

Project guidelines

- Tissue culture plants.
- Maximum of 5 red raspberry selections each year.
- Minimum of 3 grower sites each year.
- 50-150 plants/selection/site.
- Sites will include both well-drained soils and sites with root rot.
- Evaluations will be made of previous year plantings concentrating on fruit quality and yields.
- Plantings over four years old will have reached the end of their evaluation period within this program and may be removed. However, some may be left in for longer term observations.
- Advisory group will be communicating as needed to coordinate activities.
- Administrator will be giving periodic updates to participants and will disseminate and archivie information as needed.

Grower/cooperator arrangements

- Testing agreements will be created and approved by WSU and by USDA.
- Agreements will include: on-site visits by other growers and researchers (arranged and agreed to in advance); participation in the evaluation process; and a prohibition of any on-farm propagation of advanced selections.

Anticipated Benefits and Information Transfer:

- The anticipated benefit to the breeding program, growers, propagators, and wholesale nurseries include the system-wide efficiencies achieved by replacing the ad hoc grower trial system by one that is coordinated and supervised.
- The results will be transferred to users by the Northwest Berry Foundation which will be giving periodic updates to Washington red raspberry growers and the industry. Disseminating and archiving information as needed through meeting presentations, newsletters, and production of summary fact sheets.

Budget

	2023
Salaries[1/]	**$3,000**
Travel[2/]	**$403**
Outreach[3/] `	**$1,500**
Other (Propagator payments**)**[4/]	**$ 800**
Offices costs (to NBF**)**	**$ 225**
Total	**$5,928**

Budget Justification

[1/] **Salaries**

Tom Walters—7.5 days a year at 8 hours per day at $50/hour including benefits = $3,000

[2/] **Travel & related expenses**

Tom Walters—5 trips a year at 140 miles per day at $ .575 per mile = $403

[3/]**Outreach**

Outreach will be accomplished by Northwest Berry Foundation giving periodic updates to Washington red raspberry growers and the industry. Disseminating and archiving information as needed through meeting presentations, newsletters, and production of summary ‘fact sheets’

[4/] **Plant costs** ($1 per plant) $800 in 2023

Covers partial cost of plant fee: $1 per plant paid by this grant, remaining $1.50 fee per plant to be paid by grower-cooperator.

Office costs (overhead, to NBF) $225

Washington Red Raspberry Commission
Progress Report Format for 2022 Projects

Project No:

Title: Red raspberry cultivar development

Personnel:
Michael Dossett
Agassiz Research and Development Centre,
PO Box 1000, 6947 #7 Hwy.
Agassiz, BC, Canada, V0M 1A0
MDossett@BCBerryCultivar.com Tel: 604-309-0048

Reporting Period: 2020-2022

Accomplishments:
Over the last 3 years we have:

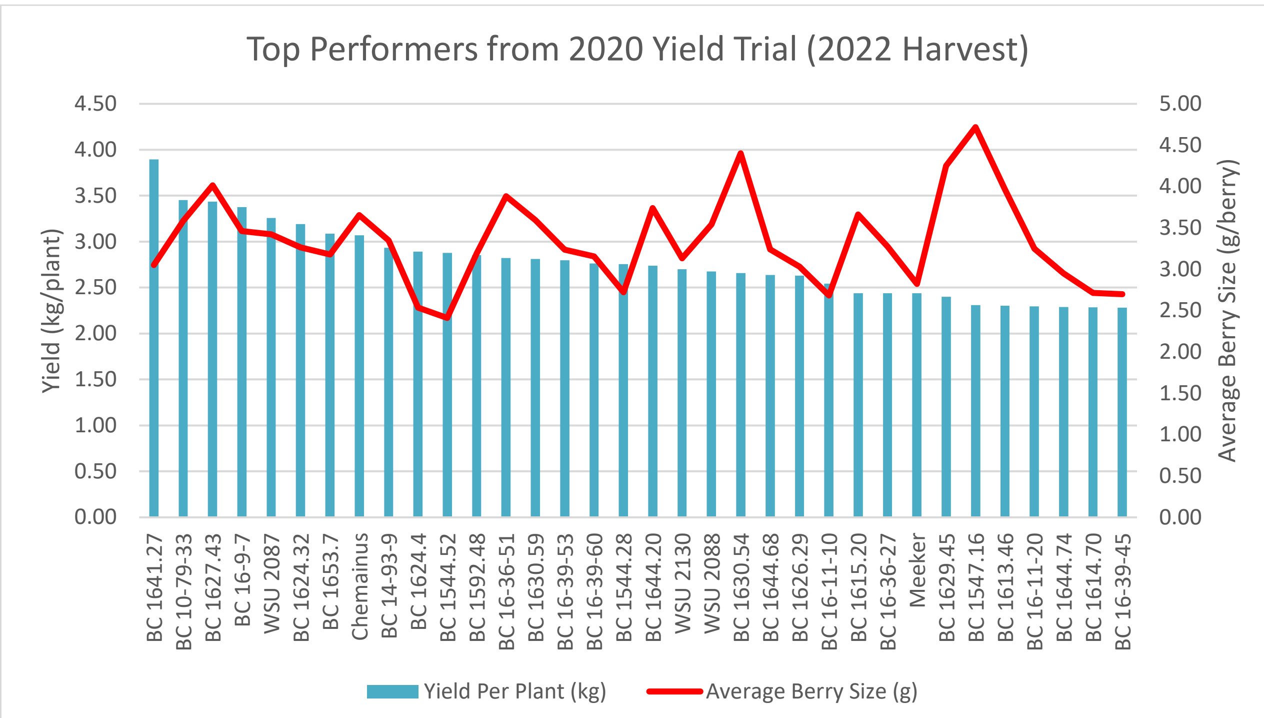
- Planted approximately raspberry 15,500 seedlings for evaluation and trial.
- Planted 330 BC, WA and Oregon selections in machine harvest trials for evaluation.
- Harvested 370 BC, WA and OR raspberry selections in machine-harvested trials.
- Distributed ~11,000 plants of BC raspberry selections for grower trial.
- Studied heritability and genetic correlations of yield components and ripening phenology to develop strategies to improve selection pressure on yield and earliness.

Results:

- High yield and later ripening are correlated (both are correlated with more berries per lateral, and this appears to be significant driver). Selecting for larger fruit size and more berries per lateral are impactful on yield, though uniformity of fruit size is a limiting factor on this selection criteria that requires consistent season-long evaluation. Increasing the number of laterals by reducing the internode length is a significant driver of yield but is a difficult trait to put selection pressure on during the fruiting season. When primocane vigor is rated based on growth during the season, high vigor genotypes tend to be somewhat lower yielding than medium vigor genotypes simply because they have longer internodes and fewer fruiting laterals as a result (the difference between 1.5 inch internode spacing and 2 inch internode spacing and the impact on yield vs. vigor is huge!).
- The strategy adopted several years ago with machine-harvesting seedling and yield trials at the Clearbrook station has very quickly resulted a high proportion of seedlings (70-80%) that look reasonable from the machine harvester in the vast majority of selections in the yield trial looking decent when evaluated afterwards in flats.
- BC 10-79-33 continued to perform well in trials, being the second highest yielding selection in the 2020 planting (so far, mirroring the 2015 planting where it was second highest in year 1 and highest in years 2 and 3). It begins ripening a few days after Meeker. Fruit are bright red. Machine harvest quality has been

somewhat inconsistent (probably due to our rotation between 3- and 4- day harvest intervals). It may have potential for IQF or for puree markets.

- BC 1653.7, which was distributed for grower trials in 2022, showed strong yields in the replicated plots (~6 tons/acre) and good machine-harvest quality
- WSU 2087 was the highlight of the WSU selections in the 2020 planting (Note 2188 is not represented in this planting), with good quality fruit and yielding ~6.25 tons/acre.
- A trio of recent selections has been identified for their strong growth, machine-harvestability, outstanding fruit quality, and good yield potential – BC 1855.11 is the largest of these and is a mid-late season ripening variety that has stood out in early evaluations in grower trials to date because of its fruit quality. BC 1855.14 is the smallest (~3-3.5 g), ripening around the same time as 'Meeker' and with outstanding firm fruit quality. BC 1855.37 is slightly softer than the other two, though still very firm and is the earliest ripening with beautiful fruit on the harvester and very good yield potential.



Publications:

Aside from reports generated for the WRRC, RIDC and AAFC there are only two recent peer-reviewed publications, though additional data is being prepared for publication.

Sapkota, S., R.R. Burlakoti, **M. Dossett**, and Z.K. Punja. 2022. Development of screening assays for pathogen virulence and resistance to *Phytophthora* root rot and wilting complex in raspberry. *Plant Disease.* https://doi.org/10.1094/PDIS-04-22-0931-RE

Sapkota, S., R.R. Burlakoti, Z.K. Punja, **M. Dossett**, and E. Gerbrandt. 2022. Understanding the root rot and wilting complex of raspberry: current research advances and future perspectives. *Can. J. Plant Path.* 44:323-344.

Current & Pending Support

Instructions: 1. Record information for active and pending projects. 2. All current research to which principal investigator(s) and other senior personnel have committed a portion of their time must be listed whether or not salary for the person(s) involved is included in the budgets of the various projects. 3. Provide analogous information for all proposed research which is being considered by, or which will be submitted in the near future to, other possible sponsors.					
Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
Michael Dossett	**Current:** AAFC, BCBC, LMHIA	$1,694,948	April 1, 2018 – March 31, 2023	55%	Blueberry Germplasm and Cultivar Development for the Pacific Northwest
	AAFC, WRRC, RIDC, LMHIA	$1,232,690	April 1, 2018 – March 31, 2023	40%	Red Raspberry Germplasm and Cultivar Development for the Pacific Northwest
	AAFC, BCSGA, LMHIA	$154,086	April 1, 2018 – March 31, 2023	5%	Strawberry Germplasm and Cultivar Development for the Pacific Northwest
Michael Dossett	**Pending*:** AAFC, BCBC, LMHIA	$1,980,000	April 1, 2023 – March 31, 2028	60%	Blueberry Germplasm and Cultivar Development for the Pacific Northwest
	AAFC, WRRC, RIDC, LMHIA	$1,155,000	April 1, 2023 – March 31, 2028	35%	Red Raspberry Germplasm and Cultivar Development for the Pacific Northwest
	AAFC, BCSGA, LMHIA	$165,000	April 1, 2023 – March 31, 2028	5%	Strawberry Germplasm and Cultivar Development for the Pacific Northwest

*Budgets for 2023-2028 policy framework application are still being developed as program guidelines from AAFC have not yet been released. Numbers here are an approximation at this time.

2023 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

New Project Proposal **Proposed Duration:** 3 years

Project Title: Red Raspberry Cultivar Development

PI: Michael Dossett
Organization: RIDC/BC Berries
Title: Geneticist/Breeder
Phone: 604-309-0048
Email: MDossett@BCBerryCultivar.com
Address: C/O Agassiz Research Centre
Address 2: 6947 Lougheed Hwy
City/State/Zip: Agassiz, BC V0M 1A0

Cooperators: Wendy Hoashi-Erhardt, Michael Hardigan

Year Initiated 2023 **Current Year** 2023 **Terminating Year** 2025

Total Project Request: **Year 1 $10,000** **Year 2 $10,000** **Year 3 $10,000**

Other funding sources: *(If no other funding sources are anticipated, type in "None" and delete agency name, amt. request and notes)*
Agency Name: Funding is being requested from the Province of BC, Raspberry Industry Development Council, Lower Mainland Horticultural Improvement Association, Agriculture and Agri-Food Canada for funding raspberry work (also pursuing funding from BC Blueberry Council, BC Strawberry Growers' Association, to support the blueberry and strawberry portions of our work).
Amt. Requested: Still being determined - See note for explanation
Notes: Our current funding cycle ends March 31, 2023. We are still waiting for an announcement of the funding program for the next 5-year policy framework (Sustainable Canadian Agricultural Partnership, or SCAP). We have some preliminary information, but until the formal announcement, details are scarce. We are currently anticipating that the 2023 growing season will be a lean funding year as we are not expecting a decision on our application until some time next fall. We are anticipating a 1:1 funding ratio of federal dollars and industry matching funds. Because project guidelines have not yet been released, the budget for our SCAP application is still being developed, but we anticipate the raspberry portion of the program will be approximately $230,000 annually. In addition to provincial support, we are pursuing in-kind contributions from Littau Harvester, some of our growers, and other sources that we can use to help leverage federal cash. It is my sincere hope that by this time next year, we will be able to report a solid breakdown of the funding for the program. In the meantime, the funding we are asking from WRRC will be used specifically to help hire summer labor for planting, harvest, and field care.

Description:
This project is to support the continued effort to breed raspberry cultivars adapted to the PNW. We will continue to cross and select from a diverse gene pool and evaluate selections with a primary emphasis on machine-harvestable yield and fruit quality and a secondary emphasis on soil-borne pests and diseases (primarily *Phytophthora* root rot but hoping to build off the NCSFR-funded nematode work on genomic prediction in future years). Specific objectives:

- Evaluate BC, WA and OR raspberry selections in replicated machine-harvested yield trials.
- Perform crosses emphasizing machine-harvestability in combination with improving other traits (e.g., fruit quality, yield, root rot, RBDV resistance, earliness) with a goal of producing 4,000-6,000 seedlings annually for evaluation.
- Evaluate seedling plots on foot and from machine-harvester for overall potential as well as the specific objectives of each cross.
- Advance the most promising selections for evaluation in grower trials to determine suitability for release and commercialization.
- Continue development and testing of molecular tools to speed up the process of accurately selecting and identifying parents and seedlings in the program with durable disease resistance and outstanding quality traits.

Justification and Background: (400 words maximum)
The red raspberry industry is facing challenges with diseases, increased production costs and competition from the global marketplace. For the last 30 years raspberry yields in Washington have been slowly but steadily declining, losing an average of 0.76% annually (19.6% drop since 1992). Genetic improvement is one of the most sustainable ways for the raspberry industry to maintain its competitive edge in the long-term. Improved quality, yield, and resistance to pests and diseases to help alleviate these problems are realistic and achievable goals that will benefit raspberry producers in Washington State.

The BC breeding program has a long history of producing cultivars with excellent fruit quality characteristics and has been making steady progress in recent years to combine this with improved machine harvestability, resistance to *Phytophthora* root rot and RBDV. In 2012, we expanded our efforts to identify machine-harvestability in our selections by contracting with a local grower to machine harvest our replicated plots. This effort was so successful we expanded it to additional plots and evaluation of seedlings in 2013. This strategy has enabled us to put selection pressure on machine-harvestability at an earlier stage in the breeding cycle, resulting in a dramatic increase in the proportion of machine-harvestable progeny under selection in the field. We plan to continue this, because we believe this is the fastest way to identify selections with merit and weed out selections that lack potential for the majority of PNW growers and are now making further adjustments to our selection strategy to allow us to more accurately put selection pressure on yield and to more readily identify seedling selections with higher yield potential.

While there are currently other raspberry breeding efforts in Washington and Oregon, each program has its strengths and weaknesses inherent in the germplasm base and breeding lines they have established through their history. While the WSU program was the first of the three to start machine-harvesting selections, our program has been able to consistently harvest seedling plots for the last 8 years which has helped us to make significant progress for this trait in our program in a relatively short time. We will continue to collaborate and exchange information and selections with the programs in Washington and Oregon so that promising material gets evaluated in as many test locations as possible and so that we can continue to combine efforts to complement the strengths of each program

Relationship to WRRC Research Priority(s):
This project directly addresses the WRRC #1 priority to develop cultivars that are summer bearing, high yielding, winter hardy, machine-harvestable, disease resistant, virus resistant and have superior processed fruit quality

Objectives:
Each of the specific objectives listed above will be attempted during the project period and each is an ongoing process that will be addressed in this funding year and in future funding years. While many inferior plants can be identified and eliminated in the early stages of the process, selections must be tested rigorously over a period of several years by the project staff and producers before they can be recommended for release and commercialization. As a result, we work in a rotating system where each year we are making new crosses, selecting from previous selections and discarding selections which don't make the grade during testing.

Procedures: (400 words maximum)
The breeding program is an ongoing project that continually makes new crosses and selections each year with the objective of developing new cultivars to support the raspberry industry. We are in the first year of a 5-year funding program called Sustainable Canadian Agriculture Partnership. The program operates on a cycle such that all activities in this project occur at some point in the season of every year. This includes:

- Making new crosses - emphasizing combining the highest yielding parents with machine harvestability and resistance to RBDV and root rot
- Planting new seedling fields from previous year's crosses for future evaluation
- Selection of mature seedling plantings with an emphasis on family yield, fruit quality and machine-harvestability
- Establish replicated trials of selections to assess machine-harvestability, quality, and yield
- Test field plantings for RBDV to establish which selections are susceptible and which may be resistant
- Screen selections in replicated trials for root rot resistance in the greenhouse to establish potential for resistance
- Propagate promising selections for further trial at our substation and on producers' fields.
- Conduct collaborative research and testing with USDA-ARS in Corvallis, WSU, AAFC, and elsewhere.

Anticipated Benefits and Information Transfer: (100 words maximum)
Specific benefits that will result from this project include:
- Continued development of new cultivars and selections that will provide alternatives for producers with high fruit quality and improved yield and resistance to pests and diseases.
- Continued development of technologies that will assist this and other breeding programs to more efficiently select promising genotypes in the future.

Results will be transferred to users through regular presentations at field days, and local meetings such as the LMHIA Short Course and the Washington Small Fruit Conference with information on new releases and selections available for testing.

Budget: *Indirect or overhead costs are not allowed* unless specifically authorized by the Board

	2023	**2024**	**2025**
Salaries[1/]	$	$	$
Time-Slip	$10,000	$10,000	$10,000
Operations (goods & services)	$	$	$
Travel[2/]	$	$	$
Meetings	$	$	$
Other	$	$	$
Equipment[3/]	$	$	$
Benefits[4/]	$	$	$
Total	**$**	**$**	**$**

Budget Justification
The funding we are asking for will be used to hire summer labor to help with planting and care of breeding plots as well as for harvest of fruit from seedlings and yield trials. We need a crew of four people to run the harvester and weigh-station for all of the breeding plots from late June-early August, with some time before and after harvest spent on vegetative data collection, planting, and field management. See note above regarding matching ratios and how these fit into the overall picture.

Progress Report
Washington Red Raspberry Commission

Project No: TBD

Title: Cooperative raspberry cultivar development program

Personnel:

Michael Hardigan, Research Geneticist, and Mary Peterson, Biological Science Technician
USDA-ARS, HCPGIRU; 3420 NW Orchard Ave. Corvallis, OR 97330

Reporting Period: 2022

Accomplishments:

The USDA-ARS-HCPGIRU breeding program in cooperation with Oregon State University, Washington State University, and the Pacific Northwest industry continues to develop and evaluate red raspberry varieties to meet the industry stated objectives.

We have continued to test USDA and WSU raspberry selections to assess their performance including yield and machine-harvested fruit quality in the northern Oregon trials at OSU-NWREC (Aurora, OR). In recent years we have generated results from replicated field trials showing that several WSU red raspberry selections that are of interest to growers, including WSU 2130, WSU 2088, and WSU 2188, were among the top performing red raspberry individuals in Oregon. This year we observed three newer WSU selections performed particularly well, with high machine harvestable yields and/or fruit quality: WSU 2087, WSU 2069, WSU 2516. Among the USDA selections, ORUS 4974-1 and ORUS 4715-2 have respectively shown the highest and second highest yields in the 2019-planted trial; both selections appeared to have somewhat better stress tolerance and fruit quality than other selections and varieties including 'Meeker' under high temperatures, and appear to be machine-harvestable. The selection ORUS 5106-1 has also shown good performance, with better machine harvestable yields than 'Meeker' and similar fruit quality, as well as previously performing well at Enfield's in Washington. These selections are being made available for propagation at North American Plants, Inc. We have several selections in machine harvest trials in northern Washington and a few of these are promising. 'Finnberry' is a new variety release from the breeding program, tested as ORUS 4716-1, it is a primocane-fruiting cultivar with good yields of fruit with excellent flavor and fresh market quality.

Results:

We have continued to move forward on the cultivar development strategy proposed to WRRC prior to 2022. In 2022, we made 55 selections (23 floricane, 22 primocane), and planted ~2,500 seedlings. Below is are some highlights from our program for 2020. Appendix II tables contain specific information on selections.

<u>Released:</u>

- **'Finnberry'** is a **primocane-fruiting** selection, with yields greater than the cultivar check 'Heritage', and with larger and much higher quality fruit. **The fruit can be picked at a range of colors from light pink to full red and still have sweetness and a good flavor.** The season starts at about the same time as 'Heritage' but it peaks and finishes about 7 d later than 'Heritage'.

Available Selections & Grower Trials

Nursery/Propagation List

In addition to any above current/future variety releases, the following have been/are being propagated for grower trials:

Floricane-fruiting:

- ***ORUS 4715-2*** – Best machine harvested fruit quality of OR selections in 2019 trial with easy release, best ability of any OR selection to hang and recover after high temperature stress.
- **ORUS 4974-1** – Machine harvested well at higher beater speed, best yields of REP selections in 2019 trial, fruit have nice color, gloss and shape, firm with low leakage, sweet/tangy flavor, nice canopy with laterals that remain upright/open under fruit load.
- ***ORUS 5106-1*** – While not as productive as 'Wakefield', has shown machine harvestable quality and yield on par with 'Meeker' in both OR and northern WA trials, with good firmness and better flavor than 'Meeker'. Contains 1/8 *R. leucodermis* genetics.
- ***ORUS 4371-4*** – High machine harvested yield in both OR and northern WA. Good winter tolerance. High quality fruit.

Primocane-fruiting:

- ***ORUS 5209-1*** – Plant has sturdy/erect canes, high yields of large, attractive fruit with few defects, excellent firmness and coherence, appear to hang well in heat, great flavor/aroma.
- ***ORUS 4487-1*** – Very early and high yielding primocane-fruiting selection.

Other:

- ***ORUS 4089-2*** – An intermediate type with weak-PF habit. Fruit are an attractive orange color and looked good in OR and northern WA. Bright firm and attractive as PF type.

**Available for trial at North American Plants, Inc.*

Grower Trials – Washington; Enfield Farms

Since 2001, we have actively trialed OR red raspberry selections at Enfield Farms (Lynden, WA), which sits on the Canadian border, to evaluate winter hardiness and machine harvestability in a commercial setting. Most but not all selections have been machine harvestable. Due to back-to-back heat damage followed by winter injury in 2021-22, many raspberry selections showed lower yields in 2022.

- **ORUS 5106-1** produced first-year yields similar to 'Meeker' with small, firm fruit that machine harvested well.
- **ORUS 4089-2** produced attractive orange primocane fruit that were too soft for machine harvest.

Grower Trials – Washington; Honcoop Machine Harvest

Since 2001, we have actively trialed OR red raspberry selections at Enfield Farms (Lynden, WA), which sits on the Canadian border, to evaluate winter hardiness and machine harvestability in a commercial setting. Most but not all selections have been machine harvestable. Due to back-to-back heat damage followed by winter injury in 2021-22, many raspberry selections showed lower yields in 2022.

- **ORUS 5104-2** has shown good plant health, vigor, and high yields of fruit that machine harvest well. Main drawback is fruit are on the lighter-colored side.

- **ORUS 4846-1** also has very nice plant health and vigor and good yields, fruit are large with good color, flavor, and attractive appearance. Better potential for fresh; fruit released on machine harvester but showed some fruit collapse and stem contamination as result.

Grower Trials – Oregon (OSU-NWREC)

Similar to what we observed in the blackberry trials, the yields of many replicated red raspberry selections we similar or even lower in 2022 compared to the 2021 "heat dome" season, possibly indicating lingering impacts on plant health or additional effects of the extended cold and wet Spring season we experienced in 2022. The USDA selections ORUS 4974-1 and ORUS 4715-2, which demonstrated the lowest heat damage in 2021, repeated as the best yielding selections in the 2019 planting in 2022, but each was lower yielding in 2022 than in 2021. **Similar to the blackberries, floricane-fruiting red raspberries at the OSU-NWREC ripened on average 14 days later in 2022 than their mean ripening dates from the previous five years.**

<u>2019 Floricane Red Raspberry Trials (Table Ry-FL 1)</u>

- **WSU 2516 (REP)** had similar yield to other top WA selections but stood out for showing much better plant health and fruit quality in a very hot 2021 season, with good machine harvest quality, fruit are a bright glossy color with good flavor. Thawed IQF quality of 2021 looked excellent in 2022 cutting.
- **ORUS 4715-2 (REP)** showed very good fruit release, nice glossy ruby color, had best machine harvest fruit quality of any OR selection under high temperatures. Thawed IQF quality of 2021 looked excellent in 2022 cutting.
- **ORUS 4974-1 (REP)** machine harvested well with slightly higher beater speed, fruit looked great on belt with good color, firmness, consistency. Best yield in 2019 trials. Main drawback is lacks strong flavor.
- **ORUS 5106-1 (REP)** has looked better than 'Meeker' for 2 years with better flavor, has **firm fruit that machine harvested well in both OR and northern WA trials**. Fruit are small, round, dark, firm, and consistent, with an appearance fairly similar to 'Wakefield'. Contains 1/8 *R. leucodermis* genetics.
- **'AAC Eden' (OBS)** from Andrew Jamieson's breeding program showed tremendous yields of very large fruit that released well during machine harvest, but lacked the firmness and durability required for a machine harvested fresh or processed variety.

<u>2020 Floricane Red Raspberry Trials (Table Ry-FL 2)</u>

- **WSU 2087 (REP)** was the best yielding replicated selection in 2022. Fruit are dark, round and firm, better than 'Wakefield'. Some stems came off with fruit.
- **WSU 2069 (REP)** was the second-best yielding replicated selection in 2022. Very pretty fruit with good color and great flavor. Quality was overall quite good but observed that firmness and coherence tailed off on warmer days, fruit took a dusty appearance if left to hang.
- **ORUS 4607-2 (OBS)** was the best yielding observation selection in 2022, matching WSU 2087. Has been high yielding and looked good in OR and WA, but feedback from WA indicates may be too soft for cultivar release.
- **ORUS 4371-4 (OBS)** was the second-best yielding observation selection in 2022. Previously showed high machine-harvestable yields and winter tolerance in WA, fruit quality is good.

<u>2019 Primocane Red Raspberry Trials (Table Ry-PR 1)</u>

- **ORUS 5209-1 (REP)** showed excellent yields last 2 years, sturdy erect canes with fruiting laterals that hang very nicely even on hot days, large semi-conical and uniform w/ coherent

drupelets, low rough/UV, firm when picked light, intense flavor, and tremendous aroma. Prioritizing for grower trials.
- **ORUS 5250-1 (REP)** shows a nice combination of very high yields and very early ripening season for primocane-fruiting type, followed by a wide ripening window. Fruit flavor and quality are good, not quite great, but combined with its yield and earliness are more than acceptable.

2020 Primocane Red Raspberry Trials (Table Ry-PR 2)

- **'Finnberry' (REP)** appeared to be negatively impacted by the odd seasonal effects in 2022, with leggier/less sturdy canes, and with fruit beginning to set and ripen very late to a degree that many did not ripen during the regular harvest season. Fruit quality and flavor were very good as usual.
- **ORUS 4487-1 (OBS)** has consistently looked good as an early season and high yielding advanced selection. Fruit are firm and consistent with great flavor and color. On the smaller side (size similar to 'Heritage') but otherwise a good fresh market raspberry.
- **ORUS 5345-1 (OBS)** produced very high yields of fruit with excellent color and flavor but low firmness and coherence.

Appendix I: Current and Pending Support Table

Current & Pending Support					
Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
Current:					
Peterson, Simons, Kubota, Ramirez, Francis, Teegarden, **Hardigan**, Luby, Bassil	Foundation for Food & Agriculture Reseearch	$1,800,000	09/2023-09/2026	10%	Advancement of Strawberries for Indoor Environments: Mapping Chemical Compositions, Genetics, and Growing Conditions for Premium Flavor
DeVetter, Bryla, **Hardigan**, Hoashi-Erhardt	USDA Specialty Crop Multi-State Program	$1,000,000	09/2023/09/2026	10%	Beat the Heat - Mitigating Heat Damage in Caneberry
Hardigan, Luby	USDA-Northwest Center for Small Fruit Research	$50,000	09/2022-09/2023	10%	Evaluating the potential of genetic markers for predicting blueberry fruit quality and ripening season in Pacific Northwest germplasm
Stockwell, Hardigan	USDA-Northwest Center for Small Fruit Research	$98,000	09/2022-09/2024	5%	Assessing the role of Gnomoniopsis idaeicola and other fungal cane blight pathogens in Blackberry Collapse
Hoashi-Erhardt, **Hardigan**, Zasada, Dossett	USDA-Northwest Center for Small Fruit Research	$135,000	09/2023-09/2025	10%	Genomic Prediction for Quantitative Resistance to Root Lesion Nematode in Raspberry
Hardigan, Strik	Oregon Raspberry Blackberry Commission	$36,940	09/2020-09/2022	10%	Cooperative Caneberry Breeding Program - Cultivar and Selection Evaluation, NWREC
Pending:					

Appendix II: Tables

Table Ry-FL 1. Fruit size and yield of floricane-fruiting red raspberry genotypes tested in OSU-NWREC 2019 trial planting, harvested from 2021-22. Yield measurements are based on machine picking using a Littau Harvester.

	Berry Size (g)	Yield (tons·a^{-1})		
Annual Mean [a]				
2021	2.86	3.16		
2022	2.40	2.89		
Genotype	2021-22	2021	2022	2021-22
Replicated [z]				
ORUS 4974-1	2.72 ab	3.93 a	3.54 a	3.74 a
*ORUS 4715-2	2.77 ab	3.78 a	3.10 ab	3.44 ab
WSU 2516	3.05 a	3.06 ab	2.69 ab	2.87 bc
*ORUS 5106-1	2.35 c	2.68 b	3.00 ab	2.84 bc
WSU 2605	2.28 c	3.18 ab	2.36 b	2.77 c
Meeker	**2.62 bc**	**2.35 b**	**2.67 ab**	**2.51 c**
Nonreplicated				
AAC Eden	**3.96**	**4.81**	**5.48**	**5.15**
ORUS 5102-2	2.55	2.86	4.35	3.61
ORUS 5106-3	1.80	3.26	2.96	3.11
ORUS 5105-1	1.97	3.25	2.96	3.10
ORUS 5104-2	2.43	3.72	2.27	3.00
WSU 2481	3.02	2.69	2.95	2.82
ORUS 5108-3	2.88	2.53	2.62	2.58
ORUS 5099-1	2.39	2.62	2.22	2.42
ORUS 4965-3	2.60	2.65	2.05	2.35
ORUS 4843-1	2.69	2.48	1.87	2.18
ORUS 5094-1	3.04	2.09	2.25	2.17

[a] Annual means based on replicated plot samples.
[z] Groups determined by t-Test (LSD) of replicated plot means, $p \leq 0.05$.
*Nursery list – available at nurseries for grower trial by request.

Table Ry-FL 2. Fruit size and yield of floricane-fruiting red raspberry genotypes tested in OSU-NWREC 2020 trial planting, harvested from 2022. Yield measurements are based on machine picking using a Littau Harvester.

	Berry Size (g)	Yield (tons·a^{-1})
Annual Mean [a]		
2022	1.89	2.70
Genotype	2022	2022
Replicated [z]		
WSU 2087	2.10 abc	4.11 a
WSU 2069	1.77 bcd	3.32 ab
*ORUS 4600-1	2.33 a	2.78 ab
ORUS 5195-2	1.77 bcd	2.66 ab
WSU 2425	1.50 d	2.61 ab
WSU 2472	1.67 cd	2.45 ab
Meeker	**1.97 abcd**	**2.39 ab**
WSU 2481	2.17 ab	2.33 ab
ORUS 4462-2	1.70 bcd	1.67 b
Nonreplicated		
*ORUS 4607-2	2.18	4.11
*ORUS 4371-4	2.36	3.19
ORUS 5195-3	1.76	2.53
ORUS 5199-1	2.58	2.30
WSU 2577	2.21	2.19
ORUS 5205-1	2.12	2.18
ORUS 5198-3	2.36	2.04
ORUS 5198-1	2.39	1.97
ORUS 5206-2	2.28	1.76
ORUS 3702-3	2.67	1.71
ORUS 5205-2	2.12	1.25
ORUS 5200-1	2.92	1.08
ORUS 5201-2	0.86	0.93
ORUS 5195-1	1.53	0.83

[a] Annual means based on replicated plot samples.
[z] Groups determined by t-Test (LSD) of replicated plot means, $p \leq 0.05$.
*Nursery list – available at nurseries for grower trial by request.

Table Ry-PF 1. Fruit size and yield of primocane-fruiting red raspberry genotypes tested in OSU-NWREC 2019 trial planting, harvested from 2020-22.

	Berry Size (g)	Yield (tons·a^{-1})		
Annual Mean [a]				
2020	3.12	1.59		
2021	2.46	1.72		
2022	2.80	2.90		
Genotype	2020-22	2021	2022	2020-22
Replicated [z]				
*ORUS 5209-1	3.1 a	2.09 a	3.73 a	2.77 a
ORUS 5250-1	3.26 a	1.83 a	3.61 a	2.45 b
ORUS 5248-1	3.19 a	2.17 a	2.49 b	1.89 c
Kokanee	**2.09 b**	**1.70 a**	**2.49 b**	**1.86 c**
*ORUS 4725-1	2.33 b	0.80 b	2.21 b	1.39 d
Nonreplicated				
ORUS 5248-3	4.32	3.02	2.21	2.59
Polka	**2.31**	**1.82**	**2.53**	**2.11**
ORUS 5211-1	2.56	2.15	2.14	1.96
ORUS 5209-2	2.00	1.39	2.95	1.94
ORUS 5218-1	2.96	1.10	2.54	1.58
ORUS 5220-1	1.82	1.84	1.58	1.40
*ORUS 4858-2	2.10	1.83	0.78	1.30
ORUS 5248-2	2.99	1.25	1.30	1.03
ORUS 5227-2	3.79	1.35	0.66	0.86

[a] Annual means based on replicated plot samples.
[z] Groups determined by t-Test (LSD) of replicated plot means, $p \leq 0.05$.
*Nursery list – available at nurseries for grower trial by request.

Table Ry-PF 2. Fruit size and yield of primocane-fruiting red raspberry genotypes tested in OSU-NWREC 2020 trial planting, harvested from 2021-22.

	Berry Size (g)	Yield (tons·a^{-1})		
Annual Mean [a]				
2021	2.03	2.27		
2022	2.63	2.83		
Genotype	2021-22	2021	2022	2021-22
Replicated				
Finnberry	**2.33**	**2.27**	**2.83**	**2.55**
Nonreplicated				
ORUS 5345-1	2.42	2.31	3.88	3.10
*ORUS 4487-1	1.91	1.76	2.73	2.24
ORUS 5467-2	2.40	1.81	2.36	2.09
ORUS 5347-1	3.43	1.57	2.41	1.99
ORUS 5465-1	3.24	1.43	1.74	1.58
Polka	**2.07**	**2.05**	**0.99**	**1.52**
ORUS 5201-2	1.91	1.27	1.72	1.49
Heritage	**1.74**	**1.15**	**1.53**	**1.34**
ORUS 5465-2	3.14	1.04	1.59	1.32
ORUS 5332-2	2.80	1.21	1.40	1.30
ORUS 5332-1	1.85	1.19	1.34	1.26
Addison	**1.03**	**1.18**	**0.15**	**0.66**
ORUS 5345-2	1.50	0.51	0.59	0.55

[a] Annual means based on replicated plot samples.
*Nursery list – available at nurseries for grower trial by request.

Table Ry-Season. Ripening season of all red raspberry genotypes tested in OSU-NWREC trial plantings in 2022, including comparisons to average ripening dates from previous five years.

		Current Year (2022)			Previous Five Years [x]		
Cultivar	Type [y]	5%	50%	95%	5%	50%	95%
ORUS 5099-1	FF	28-Jun	8-Jul	26-Jul	15-Jun	25-Jun	13-Jul
WSU 2425	FF	28-Jun	8-Jul	22-Jul	-	-	-
WSU 2605	FF	28-Jun	8-Jul	22-Jul	8-Jun	22-Jun	9-Jul
ORUS 4843-1	FF	5-Jul	8-Jul	22-Jul	15-Jun	22-Jun	13-Jul
ORUS 5195-1	FF	5-Jul	8-Jul	22-Jul	-	-	-
WSU 2472	FF	5-Jul	8-Jul	22-Jul	-	-	-
ORUS 5195-3	FF	28-Jun	12-Jul	22-Jul	-	-	-
WSU 2069	FF	28-Jun	12-Jul	22-Jul	-	-	-
*ORUS 4371-4	FF	5-Jul	12-Jul	22-Jul	23-Jun	1-Jul	13-Jul
ORUS 4462-2	FF	5-Jul	12-Jul	22-Jul	-	-	-
*ORUS 4715-2	FF	5-Jul	12-Jul	26-Jul	23-Jun	28-Jun	14-Jul
ORUS 4965-3	FF	5-Jul	12-Jul	26-Jul	23-Jun	27-Jun	4-Jul
ORUS 4974-1	FF	5-Jul	12-Jul	26-Jul	22-Jun	30-Jun	11-Jul
ORUS 5104-2	FF	5-Jul	12-Jul	22-Jul	15-Jun	25-Jun	13-Jul
ORUS 5105-1	FF	5-Jul	12-Jul	26-Jul	22-Jun	29-Jun	13-Jul
*ORUS 5106-1	FF	5-Jul	12-Jul	26-Jul	22-Jun	29-Jun	13-Jul
ORUS 5106-3	FF	5-Jul	12-Jul	22-Jul	22-Jun	25-Jun	13-Jul
ORUS 5195-2	FF	5-Jul	12-Jul	22-Jul	-	-	-
ORUS 5205-1	FF	5-Jul	12-Jul	26-Jul	-	-	-
WSU 2087	FF	5-Jul	12-Jul	22-Jul	23-Jun	1-Jul	12-Jul
AAC Eden	FF	5-Jul	15-Jul	26-Jul	15-Jun	25-Jun	13-Jul
Meeker	FF	5-Jul	15-Jul	26-Jul	22-Jun	2-Jul	14-Jul
ORUS 3702-3	FF	5-Jul	15-Jul	26-Jul	23-Jun	1-Jul	12-Jul
*ORUS 4600-1	FF	5-Jul	15-Jul	26-Jul	23-Jun	1-Jul	15-Jul
*ORUS 4607-2	FF	5-Jul	15-Jul	26-Jul	20-Jun	2-Jul	12-Jul
ORUS 5102-2	FF	5-Jul	15-Jul	26-Jul	22-Jun	9-Jul	13-Jul
ORUS 5108-3	FF	5-Jul	15-Jul	26-Jul	25-Jun	9-Jul	20-Jul
ORUS 5199-1	FF	5-Jul	15-Jul	22-Jul	-	-	-
ORUS 5200-1	FF	5-Jul	15-Jul	22-Jul	-	-	-
ORUS 5205-2	FF	5-Jul	15-Jul	26-Jul	-	-	-
WSU 2481	FF	5-Jul	15-Jul	26-Jul	15-Jun	25-Jun	13-Jul
WSU 2516	FF	5-Jul	15-Jul	26-Jul	15-Jun	29-Jun	13-Jul
ORUS 5094-1	FF	8-Jul	15-Jul	26-Jul	22-Jun	9-Jul	13-Jul
ORUS 5198-3	FF	8-Jul	15-Jul	26-Jul	-	-	-

WSU 2577	FF	5-Jul	19-Jul	26-Jul	-	-	-
ORUS 5198-1	FF	8-Jul	19-Jul	26-Jul	-	-	-
ORUS 5206-2	FF	8-Jul	19-Jul	26-Jul	-	-	-
ORUS 5206-1	FF	15-Jul	19-Jul	26-Jul	-	-	-
ORUS 5201-2	PF	26-Jul	3-Aug	23-Aug	3-Aug	17-Aug	7-Sep
ORUS 5250-1	PF	9-Aug	23-Aug	13-Sep	20-Jul	3-Aug	31-Aug
ORUS 5218-1	PF	16-Aug	23-Aug	13-Sep	20-Jul	3-Aug	31-Aug
Polka	PF	12-Aug	26-Aug	13-Sep	20-Jul	10-Aug	31-Aug
*ORUS 4725-1	PF	9-Aug	30-Aug	20-Sep	20-Jul	10-Aug	31-Aug
*ORUS 5209-1	PF	16-Aug	30-Aug	13-Sep	3-Aug	24-Aug	14-Sep
ORUS 5209-2	PF	16-Aug	30-Aug	13-Sep	3-Aug	24-Aug	7-Sep
ORUS 5211-1	PF	16-Aug	30-Aug	13-Sep	20-Jul	10-Aug	7-Sep
ORUS 5248-1	PF	16-Aug	30-Aug	13-Sep	27-Jul	10-Aug	31-Aug
ORUS 5332-1	PF	16-Aug	30-Aug	13-Sep	3-Aug	24-Aug	7-Sep
ORUS 5345-2	PF	16-Aug	30-Aug	7-Sep	3-Aug	24-Aug	31-Aug
ORUS 5465-1	PF	16-Aug	30-Aug	7-Sep	27-Jul	17-Aug	7-Sep
*ORUS 4487-1	PF	19-Aug	30-Aug	20-Sep	27-Jul	20-Aug	10-Sep
ORUS 5345-1	PF	23-Aug	30-Aug	20-Sep	3-Aug	24-Aug	14-Sep
ORUS 5467-2	PF	16-Aug	7-Sep	20-Sep	3-Aug	24-Aug	7-Sep
Crimson Treasure	PF	23-Aug	7-Sep	20-Sep	-	-	-
ORUS 5248-2	PF	23-Aug	7-Sep	20-Sep	3-Aug	24-Aug	14-Sep
ORUS 5248-3	PF	23-Aug	7-Sep	13-Sep	17-Aug	24-Aug	14-Sep
ORUS 5347-1	PF	23-Aug	7-Sep	27-Sep	24-Aug	31-Aug	14-Sep
ORUS 5465-2	PF	23-Aug	7-Sep	27-Sep	3-Aug	31-Aug	14-Sep
Kokanee	PF	26-Aug	10-Sep	27-Sep	3-Aug	24-Aug	14-Sep
Finnberry	PF	26-Aug	10-Sep	27-Sep	16-Aug	27-Aug	15-Sep
ORUS 5467-1	PF	23-Aug	13-Sep	27-Sep	-	-	-
ORUS 4723-2	PF	30-Aug	13-Sep	20-Sep	14-Aug	28-Aug	18-Sep
ORUS 5220-1	PF	30-Aug	13-Sep	20-Sep	3-Aug	24-Aug	14-Sep
ORUS 5227-2	PF	7-Sep	13-Sep	27-Sep	3-Aug	24-Aug	14-Sep
Heritage	PF	7-Sep	16-Sep	27-Sep	14-Aug	27-Aug	11-Sep
ORUS 5332-2	PF	30-Aug	20-Sep	27-Sep	24-Aug	7-Sep	21-Sep
Addison	PF	13-Sep	20-Sep	20-Sep	24-Aug	31-Aug	7-Sep
ORUS 4981-1	PF	27-Sep	27-Sep	27-Sep	-	-	-

[x] Five-year ripening date based on average of plot dates from up to five previous seasons.
[y] FF=Floricane-fruiting; PF=Primocane-fruiting.
*Nursery list – available at nurseries for grower trial by request.

Project Title: Cooperative raspberry testing and cultivar development program.

Principal Investigator: Michael Hardigan, Research Geneticist, USDA-ARS, HCPGIRU

Collaborators: Wendy Hoashi-Erhardt, Program Lead, WSU Puyallup REC
Scott Lukas, Berry Crops Research Leader, NWREC
Patrick Jones, Senior Faculty Research Assistant I, NWREC
Mary Peterson, Technician, USDA-ARS, HCPGIRU
Amanda Davis, Senior Faculty Research Assistant I, NWREC
Dimitre Mollov, Virologist, USDA-ARS, HCDPMRU
Michael Dossett, Berry Cultivar Development Inc.

Year Initiated __2013___ Current Year 2023-2024 Terminating Year _Continuing__

Total Project Request: $6,000 (Ongoing project).

Other Funding Sources:
Current and pending support form attached in Appendix I.

The USDA-ARS/OSU cooperative breeding program (Corvallis, OR) applies annually for funding from the Oregon Raspberry and Blackberry Commission (ORBC) to support the field trial component of the cooperative raspberry and blackberry breeding program based at the OSU-NWREC. The funding we are requesting is complementary.

Description of Objectives and Specific Outcomes: (<200 words)

- Development of new raspberry cultivars for the PNW in cooperation with WSU that are floricane-fruiting, high-yielding, winter hardy, machine harvestable, disease and virus resistant and have superior processed fruit quality (#1 WRRC Priority).
- Identify fresh market cultivars that provide "season extension: improve viability of fresh marketing" through floricane or primocane fruiting types (#3 WRRC Priority).

The program is focused on developing cultivars that are able to replace or complement current industry cultivars such as 'Meeker' or 'Wakefield' to support the long-term viability of the regional industry. Each year we produce new experimental selections and evaluate their performance in machine harvest trials alongside cultivars. We objectively measure yield and fruit size, subjectively evaluate machine-harvested fruit quality, and assess thawed IQF quality in collaboration with OSU Food Science.

Justification and Background: (<400 words)

The PNW is one of the most important berry production regions in the world. This success is due to a combination of an outstanding growing environment, top-notch growers, and a strong history of industry support for research and cultivar development. The USDA-ARS caneberry breeding program in Oregon is working to develop cultivars that are commercially viable for the PNW region while simultaneously providing an additional environment for evaluating and performance of USDA and WSU experimental raspberry selections, including machine harvested fruit quality, alongside cultivar standards. The raspberry breeding programs in the PNW region (Washington, Oregon, and British Columbia) have cooperatively supported raspberry improvement and cultivar development by testing and evaluating each other's experimental selections and exchanging germplasm to support development of improved populations. Genetic gains and trial data from each program benefit the broader northwest red raspberry industry.

The USDA-ARS breeding program continues to generate and evaluate red raspberries to establish a genetic baseline of high machine-harvestable yields and fruit quality. Funding is essential to support maintaining and propagating selections within the program, field costs, and machine harvest trials at the OSU-NWREC which generate valuable data each year on USDA and WSU selections and help inform their suitability for variety release.

Relationship to WRRC Research Priorities:

The objectives tie directly to the following priorities:

- Develop cultivars that are summer bearing, high yielding, winter hardy, machine-harvestable, disease resistant, virus resistant and have superior processed fruit quality (1)
- Season extension: improve viability of fresh marketing (3)

Selections are evaluated in the field for disease symptoms and their fruit are evaluated for firmness, coherence, rot, and thawed IQF quality. Therefore, our activities indirectly contribute to the following research priorities:

- Fruit rot including pre harvest, post-harvest, and/or shelf life (1)
- Foliar & Cane diseases – i.e. spur blight, yellow rust, cane blight, powdery mildew (1)
- Viruses/crumbly fruit, pollination (3)

Objectives:

The following objectives are addressed simulanteously each year:

- Develop cultivars for the Pacific Northwest that are summer bearing high-yielding, winter hardy, machine harvestable, disease and virus resistant and have superior processed fruit quality (#1 Priority).
- Develop new fresh market cultivars that provide season extension: improve viability of fresh marketing through floricane or primocane fruiting types (#3 Priority).

Procedures: (<400 words)

This is an ongoing project in which elite cultivars and selections are used as parents to generate seedling populations from which new selections can be propagated, evaluated, and either released as new cultivars or serve as parents for subsequent generations. Promising selections are exchanged between cooperating Northwest breeding programs to test performance in a wider range of commercial environments. All of the steps are taking place every year, *i.e.*, crossing, growing seedlings, selecting, propagating for field trials, submitting for virus testing and clean-up and evaluating field trials.

Typically, thirty to forty crosses are made each year. New seedling populations are annually planted and evaluated at the OSU Lewis Brown Research Farm in (Corvallis, OR).

Promising seedlings are selected and propagated for testing at the OSU North Willamette Research and Extension Center (OSU-NWREC; Aurora, OR). The most promising WSU and USDA selections that were outstanding as seedlings or performed well in other trials are planted in replicated trials (3, 3-plant replications) alongside cultivar standards. Other promising selections are planted in smaller observation trials (single, 3 plant plot). Plants in both replicated and observation plots are subjectively evaluated for traits including vigor, disease tolerance, winter hardiness, spininess, and ease of fruit removal. Fruit are machine harvested twice-weekly during the production season using a harvester donated by Littau and scored objectively for yield, berry size, soluble solids, and acidity, in addition to subjective scoring of color, firmness, coherence, and flavor. Fruit from the best selections are processed after harvest for evaluation of thawed IQF quality in the off-season (OSU Food Science – funded by separate grants).

Selections that look promising for multiple years in replicated trials plots are propagated as advanced selections for grower trials, where they can be evaluated at other locations in the Northwest for commercial viability and suitability for cultivar release. These include the formal WRRC machine harvest trials at Honcoop Farms and other grower trials near Lynden, WA.

Anticipated Benefits and Information Transfer: (<100 words)

The breeding program will develop raspberry cultivars and advanced selections with better performance or fruit characteristics than current industry standard varieties, or that will complement the production season of current industry standards. Yield and fruit quality data generated for advanced selections from the WSU programs will also be summarized and made available to assist in determining their commercial viability.

Results of all trials will be made available to the industry and presented at stakeholder meetings. Promising selections developed by the USDA will be made available at regional nurseries.

References

Finn, C.E., Strik, B.C., Yorgey, B.M., and Martin, R.R. (2013). ‘Vintage’ red raspberry. HortScience, 48(9):1181-1183.
Finn, C.E., Lawrence, F.J., Yorgey, B.M., and Strik, B.C. (2004). 'Chinook' red raspberry. HortScience, 39(2):444-445.
Finn, C.E., Lawrence, F.J., Yorgey, B.M., and Strik, B.C. (2001). 'Coho' red raspberry. HortScience, 36(6):1159-1161.

Budget:

Amount allocated by Commission for previous year: $ 6,000 **(in FY21, no FY22 proposal)**

	2021	2022	2023
Salaries[1/]	$9,000	$	$6,000
Time-Slip	$	$	$
Operations (goods & services)	$1,000	$	$
Travel	$	$	$
Meetings	$	$	$
Other[2/]	$5,000	$	$
Equipment	$	$	$
Benefits	$	$	$
Total	**$15,000**	**$**	**$6,000**

Budget Justification

[1/]Student labor (1 student GS-2, 4 months).

[2/]WRRC funds will be used only to support field operations that are essential to the core breeding program. Technician and post-doc salaries, and the bulk of the overall breeding project in Corvallis will be supported by USDA-ARS funds.

ENTOMOLOGY

A Report to the Washington Red Raspberry Commission

Title: Two-spotted mite (TSSM) Management in Raspberries

Year Initiated: 2019 **Current Year**: 2022 **Terminating Year**: 2022

Principal Investigator:
Alan Schreiber, 2621 Ringold Road, Eltopia, Wa 99301, aschreb@centurytel.net
Tom Walters, Walters Ag Research, 2117 Meadows Ln, Anacortes WA 98221
waltersagresearch@frontier.com, 360-420-2776.

Justification and Background: Historically, two-spotted spider mites have been a moderately important but manageable pest of raspberries. Red raspberries are naturally susceptible to mites. During harvest, picking machines travel through fields every 24 to 36 hours. Tractors applying pesticides twice a week and other field activities create a great deal of dust that exacerbate mite outbreaks. Growers spray for primocane suppression two to three times per season which forces mites living on weeds to move up into the canopy.

Recently Washington red raspberry growers have had increased difficulty controlling two-spotted spider mites in commercial fields. The increased difficulty in controlling mites is thought to be due to one or two reasons. First, the "recent" movement of spotted wing drosophila (SWD) into raspberry fields has resulted in an increased number of insecticides applied during the 40 or so days of harvest. This pest is particularly challenging for growers of individually quick-frozen (IQF) fruit which has zero tolerance for SWD. This problem is even more acute for growers exporting fruit as maximum residue limits (MRLs) limit products they can use. Some of the products that are considered essential to SWD control include pyrethroid insecticides which likely are fomenting mite outbreaks by disrupting the natural controls of mites. The standard miticide available for use during harvest is Acramite (bifenazate). Growers and crop advisor believe that due to heavy reliance on this product mites have developed resistance and control is failing.

There are several miticides registered for use on raspberries, but they have use restrictions that limit or prevent their use. Abamectin cannot be used near or during harvest due to the 7 day preharvest interval. Vendex and Savey have MRL restrictions that limit their use to early season. Zeal can be used, but only once and it targets eggs only, so it is used in early season when mite nymph and adult numbers are low. Kanemite is considered ineffective. Current mite programs will use Vendex or Savey early in the season followed by two applications of Acramite and one application of Zeal in mid-season and abamectin postharvest. However, growers feel that Acramite has become ineffective. Some growers insist that two spotted spider mites have developed resistance to Acramite (bifenazate). A molecular marker for bifenazate resistance in mites has been identified making detection of resistance straightforward. Six populations of TSSM from Whatcom County raspberry fields are currently in colony and are being prepped for screen for bifenazate resistance

Challenges associated with mites have increased so much that the WRRC has made this one of their top research priorities. The industry is interested in finding miticides that have new modes of action with 1 day preharvest intervals and a high level of efficacy. Ideally, with longer periods of residual control and is translaminar. And more ideally, the products can obtain MRLs in key export markets.

Materials and Methods
Research staff at Agriculture Development Group, Inc. conducted a research trial investigating the efficacy of 13 products for control of two-spotted spider mite (TSSM) in raspberry. The trial was conducted at Ferndale in Whatcom County, Washington. The experimental design for this trial was a randomize complete block with 4 replications and plot sizes of 10ft x 20ft. Applications for this trial were made with an over-the-row sprayer calibrated to apply treatment sprays at 85 gallons per acre (Photo 1).

Two applications were made on 8/29 (A) and again on 9/9 (B). To assess the mite population, 20 leaves per plot were collected and at 9/1, 9/5, and 9/12, and they were shipped to Ag Development Group for mite count. The mites were collected from the leaves using a mite-brush and counted using magnifier (Photo 2). The application was started relatively late as the trial was placed in a commercial raspberry field and the applications could not start until harvest was complete to make sure no off label residues were on harvested fruit. The grower cooperator would not allow unregistered products to be applied in his field until after harvest, thus the trial started later than was ideal. Mites were present at above action threshold levels at the first sampling immediately after harvest.

Table 1. Treatment list with application codes.

Trt No.	Treatment Name	Rate	Rate Unit	Appl Code
1	Untreated Check			
2	FujiMite SC	2	pt/a	AB
	Induce	0.125	% v/v	AB
3	Kanemite 15 SC	31	fl oz/a	A
4	Aza-Direct	3	pt/a	AB
5	Savey 50 DF	6	oz/a	A
6	Acramite 50 WS	1	lb/a	A
	Induce	0.125	% v/v	A
7	Agri-Mek	4	fl oz/a	AB
8	Brigade 2 EC	6.4	fl oz/a	AB
9	Danitol 2.4 EC	16	fl oz/a	AB
10	Oberon 2SC	16	fl oz/a	AB
11	Nealta	13.7	fl oz/a	A
12	Zeal	3	oz/a	A
13	Asana	4.8	fl oz/a	A

Results and Discussion

No phytotoxicity was observed for all treatments at any point of the trial.

There was no TSSM eggs detected for any evaluation dates. No statistical differences were noticed among treatments for mite count. The treatments of Aza-Direct, Acramite, and Agri-Mek showed 10%, 42%, and 22% numerically lower mite count compared to untreated check, respectively, on September 1. Treatments of Kanemite and Aza-Direct showed 10% and 4% numerically lower mite count compared to untreated check, respectively, on September 5. Treatments of Fujimite, Aza-Direct, Savey, Acramite, Agri-Mek, Danitol, Oberon, and Asana showed 22%, 15%, 55%, 3%, 20%, 22%, 11%, and 0.08% lower mite count compared to untreated check, respectively, on September 12. For total mite count from all three evaluation date, treatments of Fujimite, Aza-Direct, Savey, Acramite, Agri-Mek, and Danitol showed 8%, 12%, 29%, 6%, 6%, and 8% lower total mite count compared to untreated check, respectively.

In summary, results suggest a potential of Fujimite, Aza-Direct, Savey, Acramite, Agri-Mek, and Danitol for controlling TSSM in raspberry. Future research is needed to confirm the results/further evaluate the efficacy of these miticides on raspberry TTSM.

Following is a list of conventional miticides registered on raspberry in Washington as of December of 2022. The list consists of abamectin (Agri-Mek), acequinocyl (Kanemite), bifenazate (Acramite), etoxazole (Zeal), fenazaquin (Magister), fenbutatin oxide (Vendex), fenpropathrin (Danitol), hexythiazox(Savey), mineral oil (several names), propargite (Omite) and tolfenpyrad (Bexar). Data has yet to be collected on Magister, Bexar and Omite, all of which are new to raspberries. Mineral oil is an interesting case. It is commonly used in tree fruit for dormant applications for control mites, insect eggs, psyllids and control of soft bodied insects. To my knowledge this class of products have not been tried in raspberry. We propose to initiate a trial in 2023 on raspberries only using products registered on raspberries (some products previously screened were not registered but now are registered on raspberries). We propose to start early in the season and use a larger number of products than in 2022.

Conventional Miticides Registered on Raspberry, December, 2022				
Name	Reg. No.	Ingredients	IRAC #	Registrant Name
AGRI-MEK SC MITICIDE/INSECTICIDE	100-1351	ABAMECTIN	6	SYNGENTA CROP PROTECTION, INC.
AGRI-MEK SC	100-1351	ABAMECTIN	6	SYNGENTA CROP PROTECTION, INC.
KANEMITE 15 SC	66330-38	ACEQUINOCYL	20	ARYSTA LIFESCIENCE NORTH AMERICA
KANEMITE 15 SC MITICIDE	66330-38	ACEQUINOCYL	20	ARYSTA LIFESCIENCE NORTH AMERICA
BIFENAMITE 50 WDG	42750-322	BIFENAZATE	20	ALBAUGH LLC
VIGILANT 4SC	400-514	BIFENAZATE	20	MACDERMID AG SOLUTIONS INC
BIZATE 50WDG	34704-1118	BIFENAZATE	20	LOVELAND PRODUCTS INC / CROP PRODUCTION SVCS
BANTER SC MITICIDE	70506-322	BIFENAZATE	20	UPL NA INC
ENERVATE 50 WSB	91234-22	BIFENAZATE	20	ATTICUS LLC
WILLOWOOD BIFENAZATE 50WDG	87290-66	BIFENAZATE	20	WILLOWOOD, LLC -USA-
ACRAMITE-50WS	400-503	BIFENAZATE	20	MACDERMID AG SOLUTIONS INC
BIFENAMITE 4SC	42750-321	BIFENAZATE	20	ALBAUGH LLC
STIFLE WP	5481-650	ETOXAZOLE	10	AMVAC CHEMICAL CORP
INNTERVENE WSB	89167-63-89391	ETOXAZOLE	10	INNVICTIS CROP CARE LLC
ZARA WSB	91234-43	ETOXAZOLE	10	ATTICUS LLC
STIFLE WP	89799-3	ETOXAZOLE	10	RAYMAT CROP SCIENCE
INNTERVENE SC	89167-64-89391	ETOXAZOLE	10	INNVICTIS CROP CARE LLC
ZARA SC	91234-72	ETOXAZOLE	10	ATTICUS LLC
ZEAL MITICIDE 1	59639-138	ETOXAZOLE	10	VALENT USA LLC
MAGISTER SC MITICIDE	10163-322	FENAZAQUIN	21	GOWAN CO.
MERAZ MITICIDE WSP	70506-211	FENBUTATIN-OXIDE	12	UPL NA INC
VENDEX 50WP MITICIDE	70506-211	FENBUTATIN-OXIDE	12	UPL NA INC
VALENT DANITOL 2.4EC SPRAY	59639-35	FENPROPATHRIN	3	VALENT USA LLC
HEXCEL 50 DF	91234-40	HEXYTHIAZOX	10	ATTICUS LLC
HEXYGON DF MITICIDE	10163-251	HEXYTHIAZOX	10	GOWAN CO.
HEXYGON MITICIDE	10163-251	HEXYTHIAZOX	10	GOWAN CO.
SAVEY 50DF OVICIDE/MITICIDE	10163-250	HEXYTHIAZOX	10	GOWAN CO.
CLEVER 50 DF	91234-38	HEXYTHIAZOX	10	ATTICUS LLC
470 SUPREME SPRAY OIL	2935-546	MINERAL OIL		WILBUR-ELLIS COMPANY
PURESPRAY 15E	69526-8	MINERAL OIL		PETRO-CANADA DBA INTELLIGRO
LESCO HORTICULTURAL OIL PLUS	10404-121	MINERAL OIL		LESCO, INC
SUNSPRAY ULTRA-FINE SPRAY OIL	86330-11	MINERAL OIL		HOLLY FRONTIER REFINING & MARKETING LLC
440 SUPERIOR SPRAY OIL	2935-546	MINERAL OIL		WILBUR-ELLIS COMPANY
ULTRA-PURE OIL HORTICULTURAL	69526-5-499	MINERAL OIL		BASF CORP
415 SUPERIOR SPRAY OIL	2935-546	MINERAL OIL		WILBUR-ELLIS COMPANY
DAMOIL DORMANT & SUMMER SPRAY OIL	19713-123	MINERAL OIL		DREXEL CHEMICAL COMPANY
BIOCOVER MLT	34704-805	MINERAL OIL		LOVELAND PRODUCTS INC / CROP PRODUCTION SVCS
BIOCOVER UL	34704-806	MINERAL OIL		LOVELAND PRODUCTS INC / CROP PRODUCTION SVCS

GLACIAL SPRAY FLUID	34704-849	MINERAL OIL		LOVELAND PRODUCTS INC / CROP PRODUCTION SVCS
ORGANIC JMS STYLET-OIL	65564-1	MINERAL OIL		JMS FLOWER FARMS, INC
JMS STYLET-OIL	65564-1	MINERAL OIL		JMS FLOWER FARMS, INC
BIOCOVER LS	34704-808	MINERAL OIL		LOVELAND PRODUCTS INC / CROP PRODUCTION SVCS
PURESPRAY GREEN	69526-9	MINERAL OIL		PETRO-CANADA DBA INTELLIGRO
BIOCOVER SS	34704-809	MINERAL OIL		LOVELAND PRODUCTS INC / CROP PRODUCTION SVCS
MITOMAX 6EC	2749-578	PROPARGITE	12	ACETO AGRICULTURAL CHEMICALS CORP
OMITE-30WS	400-427	PROPARGITE	12	MACDERMID AG SOLUTIONS INC
OMITE-6E	400-89	PROPARGITE	12	MACDERMID AG SOLUTIONS INC
ENDOMITE	91234-33	PROPARGITE	12	ATTICUS LLC
BEXAR INSECTICIDE	71711-36	TOLFENPYRAD	21	NICHINO AMERICA, INC.

Additionally, five populations of two-spotted spider mites were collected from raspberry fields with a history of Acramite exposure. The samples were provided to Dr. Doug Walsh at Washington State University in Prosser who has the populations in colonies and will screen them for resistance to Acramite.

Table 2. ANOVA table for the mean separation of egg and mite counts for different treatments at different timing.

Pest Type					I, Insect				
Pest Code					TETRUR	TETRUR	TETRUR	TETRUR	TETRUR
Pest Scientific Name					Tetranychus urt>	Tetranychus urt>	Tetranychus urt>	Tetranychus urt>	Tetranychus urt>
Pest Name					Two-spotted spi>	Two-spotted spi>	Two-spotted spi>	Two-spotted spi>	Two-spotted spi>
Crop Type, Code					C, RUBID	C, RUBID	C, RUBID	C, RUBID	C, RUBID
BBCH Scale					BPER	BPER	BPER	BPER	BPER
Crop Scientific Name					Rubus idaeus	Rubus idaeus	Rubus idaeus	Rubus idaeus	Rubus idaeus
Crop Name					wild raspberry	wild raspberry	wild raspberry	wild raspberry	wild raspberry
Rating Date					Sep-1-2022	Sep-1-2022	Sep-5-2022	Sep-5-2022	Sep-12-2022
SE Group No.					1	3	4	4	5
Rating Type					Egg	mite	Egg	mite	Egg
Rating Unit/Min/Max					COUNT, -, -	COUNT, -, -	COUNT, -, -	COUNT, -, -	COUNT, -, -
Sample Size					10 leaves	10 leaves	10 leaves	10 leaves	10 leaves
Number of Subsamples					1	1	1	1	1
Data Entry Date					Sep-9-2022	Sep-9-2022	Sep-9-2022	Sep-9-2022	Sep-21-2022
Days After First/Last Applic.					10, 3	10, 3	14, 7	14, 7	21, 14
Trt-Eval Interval					10 DA-A	10 DA-A	14 DA-A	14 DA-A	21 DA-A
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	1*	2*	3*	4*	5*
1	Untreated Check				0.0a	40.5a	0.0a	65.5a	0.0a
2	Fujimite SC	2	pt/a	AB	0.0a	51.3a	0.0a	85.8a	0.0a
	Induce	0.125	% v/v	AB					
3	Kanemite 15 SC	31	fl oz/a	A	0.0a	40.5a	0.0a	59.0a	0.0a
4	Aza-Direct	3	pt/a	AB	0.0a	36.3a	0.0a	63.0a	0.0a
5	Savey 50 DF	6	oz/a	A	0.0a	55.0a	0.0a	91.3a	0.0a
6	Acramite 50 WS	1	lb/a	A	0.0a	23.3a	0.0a	70.0a	0.0a
	Induce	0.125	% v/v	A					
7	Agri-Mek	4	fl oz/a	AB	0.0a	31.5a	0.0a	105.5a	0.0a
8	Brigade 2 EC	6.4	fl oz/a	AB	0.0a	50.8a	0.0a	92.0a	0.0a
9	Danitol 2.4 EC	16	fl oz/a	AB	0.0a	49.5a	0.0a	84.3a	0.0a
10	Oberon 2SC	16	fl oz/a	AB	0.0a	45.8a	0.0a	117.0a	0.0a
11	Nealta	13.7	fl oz/a	A	0.0a	64.5a	0.0a	91.5a	0.0a
12	Zeal	3	oz/a	A	0.0a	52.3a	0.0a	139.3a	0.0a
13	Asana	4.8	fl oz/a	A	0.0a	73.3a	0.0a	126.5a	0.0a
LSD P=.05					.	34.65	.	63.73	.
Standard Deviation					0.00	24.16	0.00	44.44	0.00
CV					0.0	51.14	0.0	48.53	0.0
Levene's F^					.	0.44	.	0.626	.
Levene's Prob(F)					.	0.937	.	0.807	.
Shapiro-Wilk^					.	0.9652	.	0.9779	.
P(Shapiro-Wilk)^					.	0.1314	.	0.4423	.
Skewness^					.	0.3925	.	0.1908	.
P(Skewness)^					.	0.2535	.	0.577	.
Kurtosis^					.	-0.534	.	-0.6585	.
P(Kurtosis)^					.	0.4283	.	0.3294	.
Replicate F					0.000	1.039	0.000	0.743	0.000
Replicate Prob(F)					1.0000	0.3871	1.0000	0.5336	1.0000
Treatment F					0.000	1.216	0.000	1.256	0.000
Treatment Prob(F)					1.0000	0.3099	1.0000	0.2856	1.0000

Table 2. Continued.

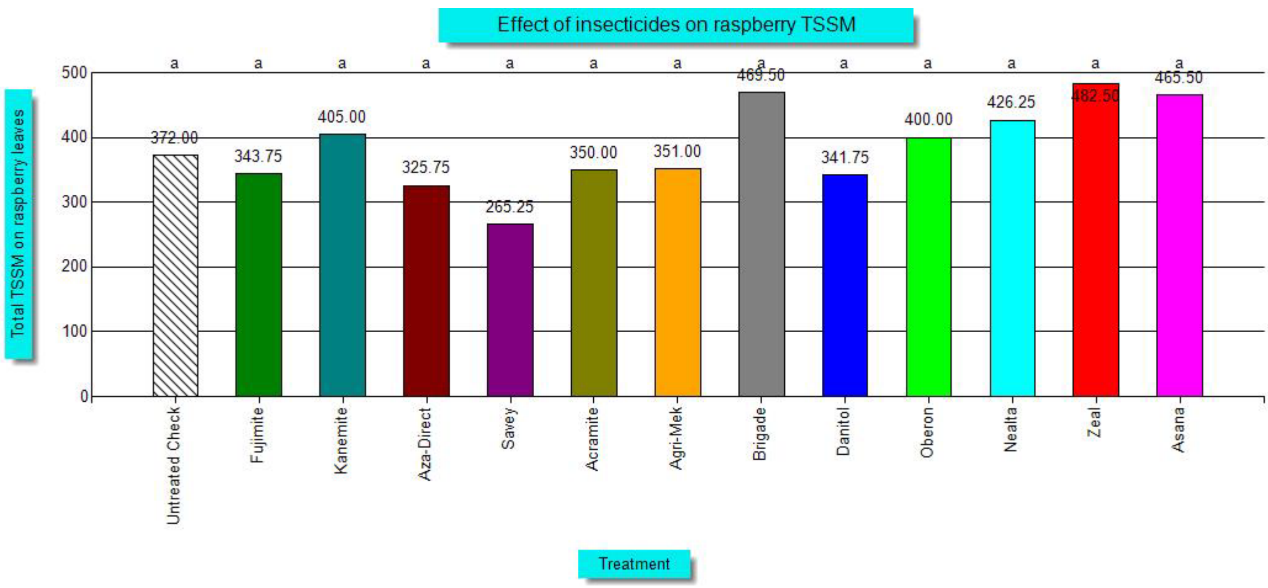
Pest Type						
Pest Code					TETRUR	TETRUR
Pest Scientific Name					Tetranychus urt>	Tetranychus urt>
Pest Name					Two-spotted spi>	Two-spotted spi>
Crop Type, Code					C, RUBID	C, RUBID
BBCH Scale					BPER	BPER
Crop Scientific Name					Rubus idaeus	Rubus idaeus
Crop Name					wild raspberry	wild raspberry
Rating Date					Sep-12-2022	
SE Group No.					7	8
Rating Type					mite	total mite
Rating Unit/Min/Max					COUNT, -, -	COUNT, -, -
Sample Size					10 leaves	10 leaves
Number of Subsamples					1	1
Data Entry Date					Sep-21-2022	Sep-21-2022
Days After First/Last Applic.					21, 14	
Trt-Eval Interval					21 DA-A	21 DA-A
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	6*	7*
5	Savey 50 DF		6oz/a	A	119a	265.3a
4	Aza-Direct		3pt/a	AB	226.5a	325.8a
9	Danitol 2.4 EC		16fl oz/a	AB	208a	341.8a
2	Fujimite SC		2pt/a	AB	206.8a	343.8a
	Induce		0.125% v/v	AB		
6	Acramite 50 WS		1lb/a	A	256.8a	350a
	Induce		0.125% v/v	A		
7	Agri-Mek		4fl oz/a	AB	214a	351a
1	Untreated Check				266a	372a
10	Oberon 2SC		16fl oz/a	AB	237.3a	400a
3	Kanemite 15 SC		31fl oz/a	A	305.5a	405a
11	Nealta		13.7fl oz/a	A	270.3a	426.3a
13	Asana		4.8fl oz/a	A	265.8a	465.5a
8	Brigade 2 EC		6.4fl oz/a	AB	326.8a	469.5a
12	Zeal		3oz/a	A	291a	482.5a
LSD P=.05					129.84	146.67
Standard Deviation					90.54	102.28
CV					36.86	26.6
Levene's F^					0.847	1.025
Levene's Prob(F)					0.604	0.446
Shapiro-Wilk^					0.9658	0.9774
P(Shapiro-Wilk)^					0.1391	0.4215
Skewness^					0.4723	-0.098
P(Skewness)^					0.1706	0.7742
Kurtosis^					-0.3542	-0.8338
P(Kurtosis)^					0.5987	0.2181
Replicate F					0.099	0.081
Replicate Prob(F)					0.9601	0.9698
Treatment F					1.390	1.575
Treatment Prob(F)					0.2157	0.1434

Means followed by same letter or symbol do not significantly differ (P=.05, LSD).
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.
* Adjusted means
Could not calculate LSD (% mean diff) for columns 1,3,5 because error mean square = 0.
^Calculated from residual.

Photo 1. Over-the-row sprayer used for applications.

Photo 2. Mite assessment in the lab.

Figure 1. Treatment effect on total number of TSSM.



Project Proposal to WRRC **Proposed Duration:** 3 Years

Project Title: Developing New Miticides on Raspberry

PI: Alan Schreiber
Organization: Agriculture Development Group, Inc.
Title: Researcher
Phone: 509 266 4348 (office), 509 539 4537 (cell)
Email: aschreib@centurytel.net
Address: 2621 Ringold Road, Eltopia, WA 99330

Cooperators: Tom Walters, Walters Ag Research

Year Initiated: 2021 **Current Year:** 2022 **Terminating Year:** 2023

Total Project Request: Year 1 - $12,000 Year 2 - $12,495 Year 3 - $12,495

Other Funding Sources: We have submitted a proposal to the Washington State Commission on Pesticide Registration to support the WRRC effort in the amount of $17,955.

Justification and Background:

Historically, two-spotted spider mites (TTSM) have been a moderately important but manageable pest of raspberries. Red raspberries are naturally susceptible to mites. During harvest, picking machines travel through fields every 24 to 36 hours. Tractors applying pesticides twice a week and other field activities create a great deal of dust that exacerbate mite outbreaks. Growers spray for primocane suppression two to three times per season which forces mites living on weeds to move up into the canopy.

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Summary of 2022. Results suggest a potential of Fujimite, Aza-Direct, Savey, Acramite, Agri-Mek, and Danitol for controlling TSSM in raspberry. Future research is needed to confirm the results/further evaluate the efficacy of these miticides on raspberry TTSM.

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Relationship to WRRC Research Priority: This project directly addresses the WRRC RFP Category "Mite Management" a number one priority of the Commission.

Objective 1. Collect information on TSSM biology – including a seasonal phenology on when mites first appear on raspberry to determine when first application should begin.

Objective 2. Generate data on fungicide efficacy against TSSM.

Objective 3. Determine if Acramite resistance is present in TSSM in Washington red raspberry.

Procedures:

Biology Data. We propose to collect data on mites from six fields with applications starting at the first detection of mites until one month after harvest. Raspberry leaves and weed leaves from the base of the plant will be collected from fields, packaged and shipped to ADG where they will be put through a mite brush and counted for each life stage by species of mite. A seasonal phenology for mites on raspberries will be constructed. Since yellow spider mite, McDaniels spider mite, and European red mite have also been known as the pests of raspberries, mites will be counted by species as well as life stages (eggs, larvae, nymphs and adults). Predatory mites such as *Neoseilulus fallacis* will be noted.

Efficacy Data. We propose to conduct a raspberry efficacy trial against TSSM. The trial would be placed in a field with detectable levels of mites with applications beginning just as mites are first detected on the leaves. Application would be applied by an over the row sprayer. The trial would be a randomized complete block design with four replications. The location would likely be in an area northeast of Lynden, WA where the PI successfully conducted a spider mite trial on raspberry in 2020. Products that are likely to be included are abamectin (Agri-Mek), acequinocyl (Kanemite), bifenazate (Acramite), etoxazole (Zeal), fenazaquin (Magister), fenbutatin oxide (Vendex), fenpropathrin (Danitol), hexythiazox(Savey), mineral oil (several names), propargite (Omite) and tolfenpyrad (Bexar). Some of these products have not been screen for mite control on raspberry such as mineral oil, Bexar, Omite and Magister which are new to raspberry. The pyrethroids are being included to determine if their use flares mites as was demonstrated in WSCPR funded research on blueberries in 2020. Growers are interested in obtaining information about Nealta, a BASF product. BASF has expressed interest in allowing Nealta to be registered on raspberry via the IR-4 Project if sufficient positive efficacy data and lack of phytotoxicity data can be demonstrated. It is our hope that based on one to two years of efficacy data that BASF will allow this product to enter the IR-4 registration process. Applications would follow labeled use patterns or proposed use patterns.

Resistance Data. We plan to collect mites after applications of Acramite during the 2023. growing seasons from multiple fields. These mites will be assayed for the genes associated with Acramite resistance.

Now, all product we plan to screen are registered on raspberries. We hope that this will allow an earlier application timing for miticides.

Anticipated Benefits and Information Transfer:

Our goal is to develop biological information that will allow improved control of mites, identification of miticides appropriate for registration, submit miticides for registrations via the IR-4 Project and determine whether resistance to Acramite is present in mites in raspberry fields. This information will be communicated to growers by providing written reports for distribution by the Washington Red Raspberry Commission and in growers meetings such as the CHS grower meeting and the Washington Small Fruit Conference.

Budget:	**2021**	**2022**	**2023**
Salaries	5,000	3,500	3,500
Operations	1,000	990	1,000
Travel	500	650	640
Contract Research*	4,000	6,200	6,200
Benefits	1,500	1,155	1,155
Total	**$12,000**	$**12,495**	**$12,495**

*The funds for Contract Research are for chemical applications by Tom Walters.

2023 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

New Project Proposal **Proposed Duration:** 3 years

Project Title: Developing an Insect IPM program for the Washington Raspberry Industry

PI: Louis Nottingham
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Co-PI:
Organization:
Title:
Phone:
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Address:
Address 2:
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Cooperators: Alan Schreiber Alan Schreiber, Agriculture Development Group, Inc.; Ben Diehl, WSU Entomology

Year Initiated 2022 **Current Year** 2023 **Terminating Year** 2025

Total Project Request: $52,535
Year 1 (2023): $ 18,575, **Year 2 (2024):** $19,245, **Year 3 (2025):** $19,943

Other funding sources:
Agency Name: *WSCPR*
Amt. Requested/Awarded: Requested $15,767 for 2023
Notes: Additional funds will be sought through other agencies including NWCSFR

Description:
The overall goal of this project is to develop improved IPM programs for spotted wing drosophila (SWD) and other pests of Western Washington Raspberries. This will be accomplished by 1) using current research and industry knowledge to develop IPM programs for SWD; 2) test IPM programs in commercial fields with grower cooperators, assess economic feasibility, and make improvements in future years; 3) develop Extension tools to aid delivery of project findings and IPM recommendations to industry stakeholders. A parallel project with similar methods will be conducted in blueberries.

Justification and Background: (400 words maximum)
(This project continued the work started by A. Schreiber in 2022.)

Spotted wing drosophila (SWD) invaded Washington state in 2009, and immediately became the raspberry industry's most economically important pest. Unlike other drosophilids, SWD has a serrated ovipositor, making it capable of laying eggs in fruit that is still ripening. Raspberries are much more susceptible to SWD than any other berries such as blueberry and strawberry, due to higher preference by the pest and longer time to harvest. At about 50% fruit color, SWD can begin ovipositing in raspberry fruit. A single SWD detection in fruit can result in rejection of an entire shipment. Unsurprisingly, Washington raspberry growers face major challenges protecting their crops from this pest.

Prior to SWD's presence in Washington, raspberry growers made four insecticides or miticides sprays per season, on average. Now, effective management requires closer to eight sprays. The increased number of sprays costs growers and additional $200/acre/year, on average, translating to $1.8 million per year across the 9,000-acre Western Washington raspberry industry. Added sprays for SWD occur near harvest and primarily include broad-spectrum chemistries in the organophosphate and pyrethroid classes. This increases the risk of secondary pest outbreaks, particularly spider mites, of which there are few effective materials available to use in raspberries. Added sprays also accelerate the development of insecticide and miticide resistance. Finally, the pesticides used for SWD are under intense scrutiny from regulators, and many will likely lose registration in the near future. Increased spraying with broad spectrum insecticides has been a necessary response to control SWD in this highly susceptible crop, but it is clearly not a long-term solution

The overall goal of this project is to develop and test improved IPM programs for spotted wing drosophila (SWD) in Western WA raspberries. This will be accomplished by comparing pest management efficacy and economic viability of season-long IPM programs against conventional standard programs in large commercial field plots. We will use yearly results and consultation with experts within industry and universities to improve programs for future years. Additionally, we will create a comprehensive Extension and outreach program associated with this project to improve communication and collaboration with industry stakeholders and provide IPM recommendations. This will involve the development of a public webpage within WSU's Extension website to provide real-time sampling data, written summaries, and recommendations.

Relationship to WRRC Research Priority(s):
This project will directly address two of the #1 priorities of the WRRC: "Management options for control of the Spotted Wing Drosophila…" and "Mite management…".

Objectives:

1) Develop raspberry IPM decision-making guidelines for SWD and secondary pests.
2) Evaluate IPM program efficacy and economic feasibility in commercial raspberry fields.
3) Establish new Extension tools that provide insect scouting data and project summaries to the industry in real-time.

*All objectives will be addressed in the 2023 funding year.

Procedures: (400 words maximum)
Obj 1. (2023-2025) In late winter of 2023, the research PI (Nottingham) and collaborator (Schreiber) will assemble a technical working group with key industry decision-makers (growers and crop advisors) to help generate guidelines for the two treatment programs: Standard and IPM. IPM programs will use pest thresholds to determine if and when sprays occur using: http://whatcom.wsu.edu/ipm/manual/rasp/docs/raspberry_scout.pdf. IPM guidelines will suggest use of selective spray products if pest thresholds are met. IPM programs may be allowed a limited number of broad-spectrum sprays in the OP and pyrethroid classes per season.

Obj. 2. (2023-2025) During each year of the project, field sites of at least 2 acres will be sampled. Sampling will occur once per week at each site for about 20 weeks, from bloom through harvest. Sampling locations within fields will be stratified to include interior and field edge zones. Pests and beneficial insects will be sampled using various methods: beat sheets, leaf inspections, lure baited SWD traps, and fruit salt baths for SWD larvae. Insect scouting data for each site will be graphed every week and provided to cooperating growers via email, alongside recommendations for that site.

At the end of each season, programs outcomes will be statistically compared among sites and treatments. Pest and beneficial insect densities will be examined as weekly and seasonal averages. Grower spray records will be collected for cost analysis and comparison to insect management outcomes (spray records will not be shared without written permission from the grower and crop consultant). A meeting will be held with the technical working group once data are analyzed to determine where improvements can be made to IPM programs for following years, and if other objectives should be included.

Obj 3. (2023-2025) We will create raspberry (and blueberry) scouting and management webpages within the WSU Extension website, where we will post weekly scouting data and IPM guidelines. Scouting data will be summarized as averages among treatment to maintain anonymity of participating growers. We will organize at least one field day for each season to discuss outcomes, gain new perspectives from the industry, and demonstrate scouting techniques (pesticide credits will be offered). At least one online webinar will be hosted by the PI to provide information to those unable to attend in-person events. The webinar will be recorded and posted to the WSU Extension website and YouTube channel (https://www.youtube.com/user/WSUCAHNRS/playlists?app=desktop).

Anticipated Benefits and Information Transfer: (100 words maximum)
This project will result in the creation of a more affordable, reliable, and sustainable insect pest management program for raspberry growers. Since the invasion of SWD, grower spray costs have increased, as have secondary pest outbreaks and the development of pesticide resistance. In addition, the loss of organophosphates and pyrethroids is looming. Building strategic IPM programs will allow growers to overcome these challenges while keeping operations costs low. This project also incorporates specific Extension approaches to deliver research-based information to stakeholders, including webpages with real-time data and recommendations, field-days, and webinars (see Obj. 3).

Budget: *Indirect or overhead costs are not allowed* unless specifically authorized by the Board

	2023	**2024**	**2025**
Salaries[1/]	$6,533	$6,794	$7,066
Time-Slip	$7,200	$7,488	$7,788
Operations (goods & services)	$200	$200	$200
Travel[2/]	$1,625	$1,625	$1,625
Meetings	$	$	$
Other	$	$	$
Equipment[3/]	$	$	$
Benefits[4/]	$3,017	$3,138	$3,264
Total	**$18,575**	**$19,245**	**$19,943**

Budget Justification
[1/] PI Nottingham 1% FTE = $1,133/yr + 4% annual increase per additional year. Diehl, research technician at 10% FTE for 12 months = $5,400 + 4% annual increase per additional year. Timeslip at 20 hrs/week for 20 weeks = $7,200 + 4% annual increase per year. All salary and wage calculations include a 4% annual increase in accordance with Washington State University policy.
[2/] One day per week for 25 weeks at 100 miles per day (Mount Vernon to Lynden). Car rental=$40/day, 1 day per week for 25 weeks = $1000; total miles per year = 2500 miles @ 20 mpg @ $5/gal = $625.
[3/] 100 sticky cards per year at $2 per card = $200
[4/] Nottingham benefits = 32.4%, Diehl benefits = 35.5%, timeslip benefits = 10.2%

Current and Pending

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
ACTIVE					
Louis Nottingham, Christopher McCullough	WSDA Specialty Crop Block Grant	249,560	2022-2025	2	Ensuring reliable pollination for Washington apples with cultural
Louis Nottingham, Robert Curtiss, Tobin Northfield	WA Tree Fruit Research Commission (Apple)	591,176	2022 - 2024	2	Quantifying codling moth capture, lure plume reach, and trap area
Louis Nottingham, Katlyn Catron, Chris Adams	WA Tree Fruit Research Commission (Cherry)	242,873	2022 - 2025	2	Developing a Leafhopper Degree-day Mgmt. Program for Cherry IPM
Louis Nottingham, Vince Jones, Robert Orpet	Fresh and Processed Pear Committees of WA	297,739	2020 - 2023	2	Developing a phenology-based management program for pear psylla
Louis Nottingham, Vince Jones, Robert Orpet	WSDA SCBG	249,926	2020 - 2023	2	Developing a phenology-based recommendation program for pear psylla
Rebecca Schmidt-Jeffris, Louis Nottingham	WA Tree Fruit Research Commission	208,590	2021 – 2023	1	Tactics to improve natural enemy releases in tree fruit
Rebecca Schmidt-Jeffris, Robin, Northfield, Louis Nottingham	Western SARE	348,733	2020 - 2023	1	Wigging out, then wigging in: Earwig capture and augmentation for biocontrol
PENDING					
Robert Curtiss, Tobin Northfield, Robert Orpet, Gwen Hoheisel, Louis Nottingham	Western SARE	344,537	2023-2026	1	Understanding Codling moth Capture for improved IPM in Modern Orchards.
Molly Sayles, Louis Nottingham, Robert Orpet	Graduate Student Western SARE	29,941	2023-2025	1	Advancing Adoption of IPM in Washington Pears
Louis Nottingham	WRRC	18,575	2023	2	Developing an Insect IPM program for the Washington Raspberry Industry
Louis Nottingham	WBC	26,690	2023	2	Developing an Insect IPM program for the Washington Blueberry Industry
Louis Nottingham	WSCPR	15,767	2023	2	Developing an Insect IPM program for the Washington Raspberry Industry
Louis Nottingham	WSCPR	22,300	2023	2	Developing an Insect IPM program for the Washington Blueberry Industry
Stuart Reitz, Alan Schreiber, Erik Wenninger, Tim Waters, Louis Nottingham	Northwest Potato Research Consortium	80,872	2023	1	Managing Insect Pests without Neonicotinoids, Pyrethroids and Organophosphates.
Stuart Reitz, Alan Schreiber, Erik Wenninger, Tim Waters, Louis Nottingham	WSCPR	34,834	2023	1	Managing Insect Pests without Neonicotinoids, Pyrethroids and Organophosphates.

Project Proposal to WRRC **Proposed Duration:** 3 Years

Project Title: Management of Slug and Snails on Raspberry

PI: Alan Schreiber
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Title: Researcher
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Cooperators: Tom Walters, Walters Ag Research

Year Initiated: 2023 **Current Year:** 2023 **Terminating Year:** 2025

Total Project Request: Year 1 - $10,833 Year 2 - $12,000 Year 3 - $12,000

Other Funding Sources: We have submitted a proposal to the Washington State Commission on Pesticide Registration to support the WRRC effort in the amount of $14,500.

Justification and Background:

Slugs are related closely to snails but have no shell. Slug damage can be distinguished easily from damage caused by other pests by the presence of slime trails. Feeding damage to foliage is removal of plant tissue between veins and on the edge of leaves. Slug damage tends to be heaviest along field margins. Weedy or grassy borders serve as excellent habitats for slugs. Slugs are active above ground primarily at night, and also in the day during mild and wet periods, at any time of year. Very little activity takes place in cold, freezing, or extremely hot weather. During the day, slugs usually are found in the soil or in crevices or cracks, to protect themselves from dehydration and predators.

A number of slug and snail species can infest raspberries. No one has carried out research on these pests in raspberries in Washington so essentially nothing is known about their biology and control. Slug damage to raspberries can be extensive near field margins. Weedy, grassy or wooded borders serve as excellent habitat for slugs, which describes most of the raspberry fields in Washington. Our most economically important species in the Pacific Northwest is the gray field slug, also known as the gray garden slug (*Deroceras reticulatum*). The European black or red slug (*Arion rufus*), the white-soled slug (*Arion circumscriptus*), the garden slug (*Arion hortensis*), the hedgehog slug (*Arion intermedius*), the dusky slug (*Arion subfuscus*), the black greenhouse slug (*Milax gagates*), the marsh slug (*Deroceras laeve*), and the three banded slug (*Ambigolimax valentianus*) are also important mollusk pests. Samples have been collected and submitted to an expert in slug and snail taxonomy at Oregon State University for identification. We are waiting for the results.

Slugs and to a less extent, snails, have always been a problem in raspberry but for whatever the reason, they have become more of a problem in the past five years. There is a belief that in recent years there have been increased rain events resulting in conditions more favorable to the development of mollusk pests. Growers have started applying more molluscicides, specifically metaldehyde baits. Slugs are very attracted to the bait, but snails are not. There are no registered baited pesticides for snails. The labeled rate allows up to 40 pounds but growers are commonly applying 5 pounds and make the applications repeatedly three times and up to 5 times. At the highest rate, metaldehyde costs about $90 an acre plus cost of application. The first application is made by mixing the product with dry fertilizer in April. Use of metaldehyde probably represents the largest or one of the largest volumes of pesticides applied in raspberries in Washington. Unfortunately, rain causes the baited pesticide to quickly degrade. Iron phosphide (i.e., Sluggo) could also be used but it has a very short period of residual control. Growers are having a terrible time controlling these pests. No one is conducting research on this topic on raspberry or berries in Washington. The most significant impact of slugs is that they move up into the canopy and hibernate. Raspberries are harvested every 36 hours and when the machines shake the raspberry plants the slugs and snails fall into the harvested fruit as a contaminant. Slugs and snails are not always separated out on the packing line and there is zero tolerance for finding mollusks in frozen raspberry products.

The raspberry industry is interested in figuring out how to improve control of slugs in raspberry, particularly looking at rate and timing of application. It is possible that earlier applications and heavier rate of application may improve control. One thing is that since slugs move into the fields from adjacent area, a higher rate of a perimeter application could be a cost-effective means of controlling the pest. We are proposing a series of trials using various registered molluscicides to determine if there are better ways to control slugs in raspberries.

Relationship to WRRC Research Priority: Snails and slugs are not listed as a research priority, but the genesis of this proposal is based on feedback from raspberry industry representatives.

Objective 1. Identify snail and slugs in raspberry

Objective 2. Develop improved molluscide use patterns to better control slugs and snails in raspberry.

Procedures:

Growers have been using a very low rate of metaldehyde of 5 pounds, due to cost concerns. The labeled rate allows up to 40 pounds. One of the trials we are proposing is to do a perimeter treatment for half of a field, treating the outside rows with a higher rate, and measuring slug numbers across transects from the perimeter inward as compared to the other half of the field that would not receive the perimeter treatment. This would be replicated across three fields. The second trial would be to look at efficacy of iron phosphide and metaldehyde at varying rates. The third trial would look at efficacy based on timing of applications. There is a school of thought that growers may not be treating early enough. So changing the timing of application may improve efficacy. This trials would be carried out in cooperation with raspberry crop advisors. Grower(s) have expressed and interest in cooperating with this trial.

We acknowledge that this is a new project and that our knowledge of this pest is limited. We are highly experience in placing trials and collecting biological data. Working with crop advisors who are experience with pest management tactics targeting mollusks and growers who are interested in improving control of the pest should allow for a success trial. We expect it will take three years for us to generate a solution on how to improve mollusk pest control.

Anticipated Benefits and Information Transfer:

Our goal is to develop biological information that will allow improved control of slugs and snails and identification of slugs and snails. This information will be communicated to growers by providing written reports for distribution by the Washington Red Raspberry Commission and in growers meetings such as the CHS grower meeting and the Washington Small Fruit Conference.

Budget:	**2023**	**2024**	**2025**
Salaries	4,000	5,000	5,000
Operations	500	500	500
Hourly Help	750	750	750
Travel	250	250	250
Contract Research*	4,000	4,000	4,000
Benefits	1,333	1,150	1,150
Total	**10,833**	**12,000**	**12,000**

*The funds for Contract Research are for chemical applications by Tom Walters.

Travel is for Dr. Walters to and from research plots. The total cost of travel is shared with other work done in the area.

WEEDS

2023 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

New Project Proposal **Proposed Duration:** 2 years

Project Title: New Technology, New Products, Better Use of Products for Raspberry Weed Management

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Co-PI: Ian Burke
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Year Initiated: 2023 **Current Year** 2023 **Terminating Year** 2024

Total Project Request: **Year 1 $** **Year 2 $** **Year 3 $**

Other funding sources:
Agency Name: Washington Commission on Pesticide Registration
Amt. Requested/Awarded: $17,955

Description: (less than 200 words) describing objectives and specific outcomes

Justification and Background: (400 words maximum)

Perennial and annual grass weeds are serious pests of raspberries. The industry had a Section 18 for several years for Chateau (flumioxazin) on Reed's canary grass and quackgrass, but the registrant stopped supporting the Section 18 and this use pattern was lost. There are several herbicides that have some potential to manage grassy weeds but due to various use restrictions, supply change issues, regulatory problems, and phytotoxicity, there are no good means to control perennial grasses in raspberry. Annual grasses are an issue as well such as *Poa annua* (bluegrass). Roundup can control weeds, but raspberries are highly sensitive and growers are highly reluctant to use the product especially as primocanes are emerging. There are several preemergent herbicides registered on raspberry, but they work on germinating grassy weed seeds not against established weeds. Further, most of the products have limited periods of residual control and eventually “break”. These products include Casoron, diuron, Alion, Treflan, Prowl, Gallery, Devrinol, Kerb, Simazine, Dual and Sinbar. Callisto, Sinbar, sulfentrazone, Matrix, Casoron, and most significantly, glyphosate, have phytotoxicity issues.

Growers are seeking contact herbicides that are effective against grasses; growers cannot get access to Poast and Fusilade, leaving clethodim as the primary product but its efficacy, particularly against perennial grasses such as canary grass and quackgrass, is not very good.

Additionally, weeds tend to be patchy in perennial production systems and ongoing project in NW WA blueberry fields found weed distribution to be at low densities (<1.5 weeds/m^2) in spring and fall assessments with few exceptions (Benedict et al., unpublished). Because weeds are patchy three scenarios can play out: 1. broadcast application of post-emergent herbicides results in the overuse of herbicides, 2. growers decide to not make broadcast applications because of low weed densities, or 3. growers rely on hand labor to remove weeds because of low weed densities. Hand weeding is labor-intensive as it relates to the non-uniform distribution of weeds within fields. While several factors determine the profitability of raspberry production, it is worthwhile to investigate more efficient ways of doing things, such as precision weed management, which can in turn generate cost savings and lead to improved net profits.

Weed-sensing sprayer technology for spot application of herbicides has been around for more than 20 years[1] with major advances during this time period[2]. These systems can reduce the need for labor, and herbicide costs, and are increasingly used to manage herbicide-resistant weeds[3]. Though the use of this technology has not been evaluated in raspberry production systems.

Relationship to WRRC Research Priority(s): Weed Management is a #3 priority. This project was developed after feedback from industry representatives described challenges associated with perennial grasses. Additionally, this project is a parallel project to one currently being funded by the Washington Blueberry Commission.

Objective 1. Screen new herbicides for control of grass weeds in raspberry. (2023)
Objective 2. Screen existing herbicides for control of grass weeds in raspberry. (2023)
Objective 3. Determine a) the economic feasibility of spot spray technology and b) estimate the return on investment under various scenarios (e.g., raspberry variety, weed density/species, herbicide costs, different technology configurations, and use in diversified farms). (2023-2024)
Objective 4. Evaluate the use of spot spray technology for use in red raspberries in western Washington in terms of efficacy and efficiency. (2023-2024)

Procedures: (400 words maximum)

This project is anticipated to take two years (2023-2024) to evaluate herbicide efficacy and spot sprayer across multiple years.

This project would consist of three experiments: 1) a preemergent herbicide trial, 2) a contact burndown herbicide trial and 3) a demonstration trial using a precision sprayer. The first two experiments address Objectives 1 and 2, while the third experiment addresses Objective 4.

Preemergent herbicide trial: registered and unregistered preemergent herbicides will be applied early in the season. The products included in this trial have not all been identified but may include sulfentrazone, rimsulfuron, pronamide, napropamide, and diuron. The trial will have four replications and plots will be 50 feet in length, potentially smaller if there is sufficient weed pressure. We estimate there will be approximately 15 entries and a single application. Schreiber will be the lead of this trial with WSU's Chris Benedict assisting.

Contact burndown herbicide trial: registered and unregistered herbicides will be applied directly to grasses in the mid-season. The products included in this trial have not been identified but may include Poast, Fusilade, clethodim, glyphosate and Chateau. The trial will have four replications and the plots will be 25 feet in length. We estimate there would be about 10 entries and expect one to two applications. Schreiber will have the lead on this trial with WSU's Chris Benedict assisting.

Precision sprayer trial: Five fields will be selected for field trials to directly compare the "business as usual" application of post-emergent herbicides alongside the use of herbicides applied with a tractor-mounted WEED-IT precision sprayer (**automated spot sprayer**). This sprayer has sensors that can identify the presence of weeds and in real-time actuate a valve to precisely apply herbicide where it is needed. In the long-run and at low weed densities it can save money by reducing herbicide costs. Chris Benedict will be the lead on this trial with Alan Schreiber assisting. The Washington Blueberry Commission is funding a parallel trial on blueberries and is purchasing the sprayer for that project.

A partial budget analysis will be conducted to estimate and compare the costs and benefits of the alternative (automated spot sprayer) against business-as-usual. This methodology addresses Objective 3. The existing raspberry enterprise budget[4], adjusted to reflect current market prices, will be used as basis for the business-as-usual scenario. In the partial budget, the net change in profit that can be expected from the alternative is estimated. The change can have one or more of the following effects: new or additional expenses; reduced or eliminated expenses; new or additional revenue; or lost or reduced revenue[5]. Results will inform us if using the automated spot sprayer for precise treatment of weeds will generate a gain or loss with respect to the current level of profit (baseline). In addition, we will undertake risk analysis by examining the sensitivity of profit in critical economic parameters, such as crop yield, output price, herbicide costs (material and labor), and fixed costs (i.e., spot spray technology and its different configurations). The return on investment for technology adoption will also be estimated given the above-mentioned sensitivity scenarios.

Anticipated Benefits and Information Transfer:

Washington red raspberry growers face increased production costs and need to identify, adopt, and employ weed management strategies that help reduce these costs. Specific weed management needs vary from producer to producer and field to field and the development of flexible weed management systems that adapt to diverse needs is necessary. This project will identify new herbicides compatible with raspberry production and outline their strengths and weaknesses. Additionally, this project will reduce the risk associated with evaluating spot spray technology for use in red raspberries.

References:

1. Steward, B. L. & Tian, L. F. Real-Time Machine Vision Weed-Sensing. in *Paper No. 983033* (1998).
2. Piron, A., Heijden, F. & Destain, M. Weed detection in 3D images. *Precision Agriculture* **12**, 607–622 (2011).
3. Cook, T. Weed detecting technology: an excellent opportunity for advanced glyphosate resistance management. *Developing solutions to evolving weed problems. 18th Australasian Weeds Conference, Melbourne, Victoria, Australia, 8-11 October 2012* 245–247 (2012).
4. Galinato, S.P. & DeVetter, L.W. 2015 Cost estimates of establishing and producing red raspberries in Washington. Washington State University Extension Publication TB21 (2016).
5. Kay, R.D., Edwards, W.M. & Duffy, P.A. Farm management. 7th ed (2012). New York: McGraw Hill.

Budget: <u>*Indirect or overhead costs are not allowed*</u> unless specifically authorized by the Board

	2023	**2024**	**2025**
Salaries[1/]	$6,659	$6,659	$
Time-Slip	$	$	$
Operations (goods & services)	$ 398	$ 398	$
Travel[2/]	$ 719	$ 719	$
Meetings	$	$	$
Other	$2,674	$2,674	$
Equipment[3/]	$	$	$
Benefits[4/]	$2,045	$2,045	$
Total	**$12,495**	**$12,495**	**$**

Budget Justification

[1/]Specify type of position and FTE.
Elizabeth Schacht 8% FTE for 5 months @ $4334.90/month total $1734
Non-student temporary employee 12hrs/month for 6 months @ 18$/hr total $1296
Suzette Galinato 8.33% FTE for 6 months @ $7260.42/month total $3629

[2/]Provide brief justification for travel requested. Travel to and from on-farm trials 1200 miles @ $0.575/mile total $690. Fuel for tractor 50 miles @ $0.575/mile total $29

[4/]Included here are tuition, medical aid, and health insurance for Graduate Research Assistants, as well as regular benefits for salaries and time-slip employees.
Benefits for E. Schacht @ 42.5% total $737
Benefits for Non-student temporary employee @10.2% total $132
Benefits for S. Galinato @ 32.4% total $1176

Other is for Schreiber's work on the spot sprayer project.

A total of $4,805 is to support Dr. Galinato for the economics portion of this this trial.
A total of $5,016 is to support Chis Benedict's field work.
A total of $2,674 is to support Dr. Schreiber's work on this project.

PHYSIOLOGY

Washington Red Raspberry Commission Progress Report

Project No: 142522

Title: Calcium accumulation and increasing fruit uptake in floricane raspberry

Personnel:
PI: Lisa DeVetter, Associate Professor of Horticulture at WSU, Mount Vernon, WA
Co-PI: Dave Bryla, Research Horticulturist at USDA-ARS, Corvallis, OR
Student: Alexandre Dias Da Silva, WSU Horticulture
Cooperator: Riley Spears @ Rader Farms

Reporting Period: 2022

Accomplishments:

- January-May, 2022 – Developed sampling protocol, identified industry cooperator, and established sampling locations.

Source: Kozhar and Peever (2018) *Phytopathology*.

Figure 1. Stages raspberry fruits were sampled.

- May-August, 2022 – Sampled 'Meeker', 'WakeField', and 'WakeHaven' developing raspberry fruits every two weeks. Stages sampled are shown in Fig. 1. Collected samples were ground and sent to co-PI Bryla's lab for chemical nutrient analyses.
- August 2022 – Sampled leaves and soil. Samples were sent to Brookside for chemical nutrient analyses.
- November 2022 – Initial analysis and presentation of fruit, leaf, and soil nutrient results with an emphasis on calcium (Ca) at the Washington Small Fruit Conference.
- December 2022 – Assessment of timing of epicuticular wax formation using scanning electron microscopy (SEM) at Western Washington University.
- Results revealed peak periods of Ca uptake, how uptake and accumulation of Ca varies by cultivar, and when epicuticular wax forms on the surface of raspberry fruits. This information will inform optimal timing of Ca foliar- and soil-applied fertilizers and our treatments planned for the next phase of this project.

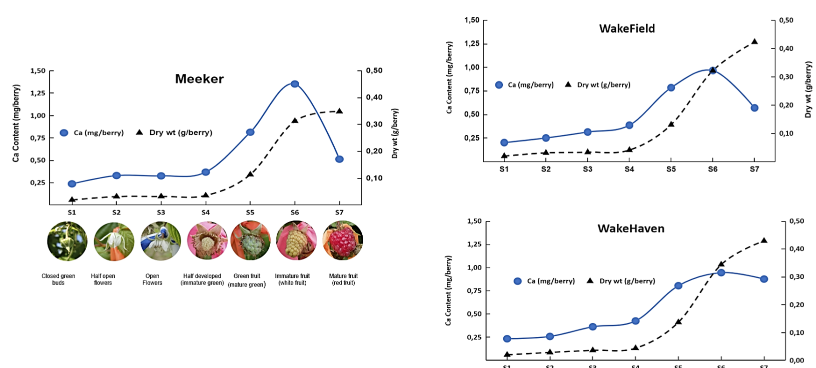

Figure 2. Patterns of calcium (Ca) uptake in 'Meeker', 'WakeField', and 'WakeHaven' developing raspberry fruits. Larger figures available upon request.

Results:

- The peak period of Ca uptake across all cultivars is between S4 -S6 (Fig. 2), which we hypothesize is the optimal time to apply Ca fertilizers (next year's field trial should validate this). Beyond those stages, minimal-to-no uptake in the fruit or receptacle tissue is occurring.
- Fruit and receptacle uptake of Ca is greatest in 'Meeker' through S6, after which 'WakeHaven' has greater Ca levels in fruits at S7.

Publications: *In preparation.*

2023 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

Project No: 142522 **Proposed Duration:** 3 years

Project Title: Calcium accumulation and increasing fruit uptake in floricane raspberry

PI: Lisa DeVetter
Organization: Washington State University
Title: Associate Professor
Phone: 360-848-6124
Email: lisa.devetter@wsu.edu
Address: 16650 WA-536
City/State/Zip: Mount Vernon/WA/98221

Co-PI: Dave Bryla
Organization: USDA-ARS
Title: Research Horticulturist
Phone: (541) 738-4094
Email: david.bryla@usda.gov
Address: 3420 NW Orchard Ave
City/State/Zip: Corvallis/OR/97330

Cooperators: None

Year Initiated 2022 **Current Year** 2023 **Terminating Year** 2024

Total Project Request: $40,493 **Year 1** $11,042 **Year 2** $13,774 **Year 3** $15,677

Other funding sources: Northwest Center for Small Fruits Research
Amt. Requested/Awarded: $165,202
Notes: Although well-received and highly ranked, the proposal was not funded. We will resubmit the proposal in 2023.

Description:
Calcium (Ca) is a widely applied macronutrient associated with plant health and fruit quality. However, information guiding efficacious use of Ca fertilizers is lacking, particularly for raspberry. This project will address this information gap through the following research and outreach objectives: 1) Determine timing of Ca accumulation across different stages and periods of fruit development in raspberry; 2) Evaluate methods to increase Ca concentrations in raspberry leaves and fruits and assess their impacts on yield and fruit quality; and 3) Disseminate findings to the raspberry industry. Specific outcomes of this project include data-driven recommendations on application timing and sources of Ca fertilizers, as well as their net impacts on raspberry yield and fruit quality.

Justification and Background:
Calcium is an important macronutrient associated with plant health and fruit quality in many horticultural crops. Multiple studies have documented the consequences of insufficient Ca, such as bitter pit in apple (*Malus domestica*), blossom end rot in tomato (*Solanum lycopersicum*), and premature fruit drop in 'Draper' blueberry (*Vaccinium corymbosum*) (Ferguson and Watkins, 1989; Gerbrandt et al., 2019; Ho and White, 2005). Calcium may be deficient for multiple reasons, including an overall lack of Ca in the soil solution or imbalances with other nutrients (K, Mg, etc.) in the rhizosphere.

To mitigate deficiencies and imbalances, growers often apply Ca fertilizers to soil or plant canopies (i.e., "foliar feeding"). However, information guiding and on the overall efficacy of these applications is mixed or lacking, particularly for raspberry. Vance et al. (2017) found foliar applications of Ca had no effect on fruit quality or shelf life in raspberry (*Rubus idaeus*), blueberry, strawberry (*Fragaria ×ananassa*), and blackberry (*Rubus* subgenus *Rubus*). Arrington and DeVetter (2017) also found similar results for commercially available foliar and soil-applied Ca in blueberry. In contrast, Gerbrandt et al. (2019) found foliar Ca was able to correct deficiencies in blueberry when applied frequently and at high concentration from mid-bloom onward. Furthermore, calcium chloride was found to reduce raspberry softening and respiration rate in postharvest storage (Lv et al., 2020).

The reason for these mixed results is likely attributed to timing of Ca application. As a relatively mobile nutrient in the soil, accumulation of Ca in plant tissues, including fruit, is driven by transpiration and the concentration of Ca in the xylem fluid. Fruits have a limited period whereby their stomata are open and can take up nutrients in their tissues either by foliar applications or nutrients dissolved in the soil solution (Yang et al., 2019). Surfactant use is another variable that can influence results. Further research is required to advance the understanding of Ca uptake, accumulation, and efficacy of fertilizer applications. This proposal addresses this information gap for floricane raspberry grown in northwest Washington. Completing this proposed research will contribute to the developing literature on Ca fertilizer application. Importantly, completion of this research will also provide growers targeted information on application timing and sources of Ca fertilizers, as well as their net impacts on raspberry yield and fruit quality. This is a new project proposal and does not relate to other ongoing projects in British Columbia, Idaho, and Oregon.

Relationship to WRRC Research Priority(s):
This proposal addresses the third-tier priority, "Nutrient Management – Revise OSU specs, Consider: timing, varieties, appl. techniques, calcium, nutrient balance".

Objectives:

1. Determine timing of calcium accumulation across different stages and periods of fruit development in floricane raspberry (Year 1 - complete).
2. Evaluate methods to increase calcium concentrations in raspberry leaves and fruits and assess the impacts on yield and fruit quality (Years 2-3).
3. Disseminate findings (Years 1-3).

Procedures:
Objective 1. In 2022 we measured Ca concentrations in developing fruits of 'Meeker', 'WakeField', and 'WakeHaven' at a single commercial site in Whatcom County, Washington. All available stages were sampled every two weeks from May through August. This sampling strategy enabled timing of Ca accumulation across different developmental stages to be assessed (see progress report). In addition, leaf and soil macro- and micronutrient concentrations were measured in August to assess nutrient status and relate it to fruit nutrient data. Scanning electron microscopy (SEM) was used to evaluate the timing of epicuticular wax formation.

Objective 2. To evaluate methods to increase Ca concentrations in raspberry leaves and fruits, a two-year on-farm trial will be established in 2023 with a grower-cooperator in Lynden, Washington. Given observed differences among cultivars in 2022, we will use two cultivars, 'Meeker' and 'WakeHaven', for this objective. Our treatments will include: 1) foliar applications of calcium chloride; 2) soil applications of lime, gypsum, or fertigated Ca (selection will depend on soil conditions at the experimental site and grower input); and 3) an untreated control. These treatments will be arranged in a randomized complete block design and applied to 60-ft-long plots replicated four times per cultivar. Calcium applications will follow the label and will be applied in 2023 and 2024. In both years, we will measure baseline and postharvest soil pH, EC, and macro- and micronutrients. Foliar and fruit nutrient analyses will also be completed yearly during standard tissue sampling times (Aug. 1). Fruit and receptacle tissues will be evaluated separately at stages S6 and S7 to determine Ca partitioning between fruits and the receptacles.

Machine-harvestable yield and fruit quality (average berry size, firmness, total soluble solids, pH, TA, and crumbliness) will also be measured yearly to determine how the treatments impact these variables. If we see differences in Ca in the fruits based on our treatments applied in 2023, we will develop a protocol in 2024 to assess resistance to shattering during IQF process. Our tentative plan is to freeze the berries in liquid nitrogen and use controlled drops from a fixed height for the test. These measurements will help us relate the role of Ca on fruit and processing quality.

Objective 3. Results will be shared annually at regional conferences and field days. At the end of the project, we will create an extension factsheet that translates study findings into grower recommendations.

Anticipated Benefits and Information Transfer:
Results from this project will provide information on how growers can be strategic with Ca fertilizer applications and their overall net effects on yield and fruit quality variables. In turn, strategic applications will allow growers to be more efficient and make cost-effective decisions when it comes to applying this important nutrient. Information will be transferred annually via regional conferences and field days. In addition, we plan to create and distribute a factsheet that translates result findings into grower recommendations.

References:
Arrington, M., & DeVetter, L. W. (2017). Foliar applications of calcium and boron do not increase fruit set or yield in northern highbush blueberry (*Vaccinium corymbosum*). HortScience, 52(9), 1259-1264.

Ferguson, I. B. & Watkins, C. B. (1989). Bitter pit in apple fruit. Hort. Rev. 11, 289 355.

Gerbrandt, E. M., Mouritzen, C., & Sweeney, M. (2019). Foliar calcium corrects a deficiency causing green fruit drop in 'Draper' highbush blueberry (*Vaccinium corymbosum* L.). Agriculture, 9(3), 63.

Ho, L. C., & White, P. J. (2005). A cellular hypothesis for the induction of blossom-end rot in tomato fruit. Annals of Botany, 95(4), 571-581.

Lv, J., Han, X., Bai, L., Xu, D., Ding, S., Ge, Y., ... & Li, J. (2020). Effects of calcium chloride treatment on softening in red raspberry fruit during low-temperature storage. Journal of Food Biochemistry, 44(10), e13419.

Vance, A. J., Jones, P., & Strik, B. C. (2017). Foliar calcium applications do not improve quality or shelf life of strawberry, raspberry, blackberry, or blueberry fruit. HortScience, 52(3), 382-387.

Yang, F. H., DeVetter, L. W., Strik, B. C., & Bryla, D. R. (2020). Stomatal functioning and its influence on fruit calcium accumulation in northern highbush blueberry. HortScience, 55(1), 96-102.

Budget: *Indirect or overhead costs are not allowed* unless specifically authorized by the Board

	2022	2023	2024
Salaries[1/]	$2,118	$7,530	$7,831
Time-Slip[2/]	$3,456		
Operations (goods & services)[3/]	$1,730	$1,984	$3,436
Travel[4/]	$522	$522	$522
Meetings			
Other[5/]	$800	$0	$0
Equipment			
Benefits[6/]	$ 2,416	$3,738	$3,888
Total	$11,042	$13,774	$15,677

Budget Justification

[1/] Technical support for data collection and processing in the Small Fruit Horticulture program for Brain Maupin (1 month at $4,560/month) and Emma Rogers (1 month at $3,024/month) in Years 2 and 3.

[2/]No timeslip in Years 2 and 3.

[3/]Field work supplies, soil, leaf, and fruit tissue analyses, shipping, and publications.

[4]/Travel for Small Fruit Horticulture program for roundtrip travel for field data collection (90 miles round trip @ $0.58/mile for 10 trips per year).

[5/]No subcontract for Bryla requested for Years 2 and 3.

[6/]Benefits for technicians in Small Fruit Horticulture (Brian Maupin @ 44% and Emma Rogers @ 58%).

*Approved by Stacy Mondy on Dec. 6, 2022.

CURRENT AND PENDING SUPPORT

Name: Lisa Wasko DeVetter

Instructions:

1. Record information for active and pending projects, including this proposal.
2. All current efforts to which project director(s) and other senior personnel have committed a portion of their time must be listed, whether or not salary for the person involved is included in the budgets of the various projects.
3. Provide analogous information for all proposed research which is being considered by, or which will be submitted in the near future to, other possible sponsors.

NAME (List.PI #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
Iorizzo, M., P. Munoz, J. Zalapa, N. Bassil, D. Main, D. Chagne, L. Giongo, K. Gallardo, E. Canales, A. Atucha, L.W. DeVetter	USDA NIFA SCRI	$7,900,000	9/2019-8/2023	3%	VacciniumCAP: Leveraging genetic and genomic resources to enable development of blueberry and cranberry cultivars with improved fruit quality attributes
Lukas, S., L.W. DeVetter, B. Strik, D. Bryla, J. Fernandez-Salvador, and S. Galinato	USDA NIFA ORG	$500,000	8/2019-7/2023	1%	Management techniques to optimize soil pH and nutrient availability in organic highbush blueberry grown east of the Cascade Rang
Sankaran, S., A. Carter, K, Evans, K. Garland-Campbell, S. Ficklin, S. Gupta, A. Kalyanaraman, L. DeVetter, R. McGee, and S. Serra	NSF REU	$389,170	1/2020-12//2022	3%	REU site: Phenomics data integration and analytics in crop improvement
Isaacs, R., R. Mallinger, L. DeVetter, S. Galinato, P. Edgar, and A. Melathopoulos	USDA NIFA SCRI	$4,000,000	10/2020-9/2024	10%	Optimizing blueberry pollination to ensure future yields
DeVetter, L.W., J. Davenport, G. Hoheisel, and G. LaHue	NCSFR	$141,258	9/2020-9/2023	4%	Optimizing nutrient management for organically grown blueberries east of the Cascade Range

CURRENT AND PENDING SUPPORT

DeVetter, L.W., G. LaHue, M. Borghi, and A. De La Luz	WBC	$22,081	1/2021-12/2022	3%	Pollinator attraction - Nectar, pollen, and assessment of new technologies
Gramig, G., L.W. DeVetter, S. Galinato, D. Bajwa, and S. Weyer	USDA OREI	$1,354,554	10/2021-9/2025	5%	MulcH_2O: Biodegradable composite hydromulches for sustainable organic horticulture
DeVetter, L.W., C. Luby, C. Mattupali, J. DeLong, V. Stockwell, and S. Lukas	WBC	$13,480	1/2022-ongoing	5%	Evaluating new blueberry cultivars and advanced selections in the Pacific Northwest
DeVetter, L.W. and D. Bryla	WRRC	$60,386	1/2021-12/2023	5%	Calcium accumulation and increasing fruit uptake in floricane raspberry
Morandin, L., K. Rourke, A. Melathopoulos, L.W. DeVetter, R. Isaacs, and T. Ricketts	USDA Multi-State	$554,436	4/2022-3/2025	5%	Optimization of habitat to support pollinators and reduce pests: Removing barriers to habitat adoption in highbush blueberry
DeVetter, L.W., D. Bryla, D., M. Hardigan, M. Zamora Re, K. Gallardo, S. Galinato, and W. Hoashi-Erhardt	USDA Multi-State	$717,637	10/2022-9/2025	10%	Beat the heat - Mitigating heat damage in caneberry
DeVetter, L.W., K. Englund, T. Marsh, J. Goldberger, S. Agehara, and S. Sistla	USDA NIFA SCRI	$8 mil	9/2022-10/2026	15%	Improving end-of-life management of plastic mulch in strawberry systems

PENDING:

Hoashi-Erhardt, W., and L.W. DeVetter	WRRC	$73,965	1/2023-12/2023	15%	Red Raspberry Breeding, Genetics and Clone Evaluation
Xuejun. P., Y. Yuan, T. Li, and L.W. DeVetter	USDA NIFA AFRI	$1 mill	1/2023-12/2025	10%	Biobased, fully soil-biodegradable mulch films prepared from biomass for sustainable bioeconomy

CURRENT AND PENDING SUPPORT

Name: David Bryla

Instructions:

1. Record information for active and pending projects, including this proposal.
2. All current efforts to which project director(s) and other senior personnel have committed a portion of their time must be listed, whether or not salary for the person involved is included in the budgets of the various projects.
3. Provide analogous information for all proposed research which is being considered by, or which will be submitted in the near future to, other possible sponsors.

NAME (List.PI #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
Current:					
Bryla, D.	Oregon Blueberry Commission	$41,795	07/01/19 – 06/30/23	2%	Comprehensive management strategies for use of biostimulants in blueberry
Lukas, S., DeVetter, L., Bryla, D., Strik, B., Fernandez-Salvador, J., Galinato, S.	USDA NIFA Organic Transitions Grant #2018-03571	$485,857	08/01/19 – 07/31/23	3%	Management techniques to optimize soil pH and nutrient availability in organic highbush blueberry grown east of the Cascade Range
Bryla, D.	Oregon Blueberry Commission	$32,360	07/01/20 – 06/30/23	2%	Improved practices for assessing plant water needs and scheduling irrigation in blueberry
Bryla, D.	Netafim International	$50,000	01/01/21 – 12/31/23	2%	A research trial on practices for improving drip irrigation of blueberry in substrate
Bryla, D.	Brandt	$15,130	01/01/21 – 12/31/22	2%	Evaluation of GlucoPro on blueberries in the Pacific Northwest
Bryla, D., DeVetter, L., Yang, W.	Washington and Oregon Blueberry Commissions	$31,120	07/01/21 – 06/30/23	2%	Fertigation practices for increasing calcium content and improving fruit quality and shelf life of conventional and organic blueberries

CURRENT AND PENDING SUPPORT

Bryla, D.	Northwest Center for Small Fruits Research	$119,422	10/01/21 – 09/30/24	5%	Evapotranspiration and crop coefficients from lysimeter measurements of blueberry
Bryla, D.	Oregon Raspberry and Blackberry Commission	$7,720	07/01/22 – 06/30/23	2%	Irrigation strategies for optimizing water use efficiency and improving fruit quality and cold hardiness in trailing blackberry
DeVetter, L. and Bryla, D.	Washington Red Raspberry Commission	$11,042	7/01/22 – 6/30/23	2%	Calcium accumulation and increasing fruit uptake in floricane raspberry
Singh, S., Lukas, S., Bryla, D., DeVetter, L.	Washington Blueberry Commission	$8,457	07/01/22 – 06/30/23	1%	Enhancing the health of permeable soils to support blueberry production east of the Cascades
Bryla, D.	Northwest Center for Small Fruits Research	$92,612	10/01/22 – 9/30/25	5%	Irrigation strategies for handling heat and improving production, plant health, and cold hardiness in trailing blackberry
DeVetter, L., Bryla, D., Hardigan, M., Peters, T., Gallardo, K., Galinato, S., Benedict, C., Zamora Re, M., Hoashi-Erhardt, W.	USDA Specialty Crop Multi-State Program	$734,387	10/01/22 – 09/30/25	3%	Beat the heat - mitigating heat damage in caneberry
Pending:					
Jin, X., Navab-Daneshmand, T., Bryla, D.	USDA NIFA AFRI – program area priority code A1411 (Water Quantity and Quality)	$750,000	06/01/23 – 05/31/27	4%	Nutrients and clean water recovery from waste for sustainable food production (this proposal)
Bryla, D.	Oregon Blueberry Commission	$11,200	07/01/23 – 06/30/24	2%	Improved practices for assessing plant water needs and scheduling irrigation in blueberry
Zamora Re, M., Bryla, D., Udell, C.	Oregon Blueberry Commission	$14,997	07/01/23 – 06/30/24	1%	Developing advanced tools for monitoring crop water use and scheduling irrigation in blueberry

CURRENT AND PENDING SUPPORT

Bryla, D., DeVetter, L., Yang, W.	Washington and Oregon Blueberry Commissions	$17,400	07/01/23 – 06/30/24	2%	Fertigation practices for increasing calcium content and improving fruit quality and shelf life of conventional and organic blueberries
Bryla, D.	Oregon Raspberry and Blackberry Commission	$8,450	07/01/22 – 06/30/23	2%	Irrigation strategies for optimizing water use efficiency and improving fruit quality and cold hardiness in trailing blackberry
DeVetter, L. and Bryla, D.	Washington Red Raspberry Commission	$21,329	7/01/23 – 6/30/24	2%	Calcium accumulation and increasing fruit uptake in floricane raspberry

PATHOLOGY
VIROLOGY

Project Title: Virus testing of PNW public raspberry breeding programs.

Principal Investigator: Michael Hardigan, Research Geneticist, USDA Corvallis

Collaborators: Wendy Hoashi-Erhardt, Program Lead, WSU Puyallup REC
Dimitre Mollov, Research Plant Pathologist, USDA Corvallis
Scott Lukas, Berry Crops Research Leader, NWREC
Patrick Jones, Senior Faculty Research Assistant I, NWREC
Mary Peterson, Technician, USDA Corvallis

Year Initiated __2023___ Current Year 2023-2024 Terminating Year _2025_

Total Project Request: $18,000 ($6000/yr, over next 3 years)

Other Funding Sources:
Current and pending support form attached in Appendix I.

The USDA-ARS (Corvallis, OR) will request matching funding from the Oregon Raspberry and Blackberry Commission (ORBC). In the future, WSU and OSU will leverage funding from the Northwest Center for Small Fruit Research to support virus testing of field plots at core research locations as well as virus clean up for advanced selections entering nursery propagation.

Description of Objectives and Specific Outcomes: (<200 words)

- Testing field plots at breeding program core research and propagation locations for viruses common in PNW in order to verify clean or infected status.
- Maintaining breeding populations of clean, virus-free plant material to support efficient generation of new breeding families and advanced slections.
- Updated report of virus infection-status and susceptibility following each season.

Annual virus testing of field plots at research sites critical to the USDA and WSU breeding programs will mitigate the spread of common viruses and prevent the accumulation of virus-infected plant material in our breeding populations. This will ensure the health of experimental families, seedlings, and advanced selections. The goal is to maintain current levels of breeding efficiency while lessening the need for lengthy "clean-up" efforts when viruses are discovered in varieties pending distribution or release. Furthermore, our testing reports will generate valuable information regarding the susceptibility of current and new selections and varieties to virus infection under PNW field conditions.

Justification and Background: (<400 words)

Regular testing for infection of plant material by common viruses is an essential function for breeding programs, especially with clonally propagated crops such as raspberry. The availability of clean plant material is necessary to maintain breeding efficiency. Accumulation of viruses within breeding populations can limit the capacity for generating new and healthy seedling families. Additionally, virus infections interfere with unbiased assessment of seedling families and introduce error into the selection and evaluation of new and promising individuals. Viruses are moved by arthropods, nematodes, or pollen and raspberry field plots are susceptible to the accumulation of viruses when maintained over multiple years. These include foundation blocks used for the preservation of important germplasm and parental material, as well as long-term, on-farm trial locations used to evaluate selections and generate the data critical for determining their performance and commercial potential. When virus testing services are not available to plant breeders at critical decision points for crosses, selection, advancement, and distribution, delays of years can impact the plant breeding cycle. This slows the ability of growers to conduct farm trials and reduces their access to competitive cultivars.

Recent shifts in the funding for the Clean Plant Network run by USDA-APHIS that conducts virus testing for the USDA-ARS and WSU small fruit breeding programs have lead to gaps in virology services. This proposal requests funds to support supplies, reagents, and technician time for virus testing of raspberry advanced selections. The immediate impact will be to mitigate the spread of common plant viruses impacting small fruit crops in the PNW at core breeding program field sites, reducing negative impacts on the breeding programs ability to generate new and clean plant material.

Virus testing and infection-status information provided in annual reports can provide a valuable and cumulative source of information on the short- and long-term susceptibility of PNW germplasm to virus infection. This information could become a useful resource for researchers, as well as for growers and nursery professionals, to flag raspberry material susceptible to early infection.

Relationship to WRRC Research Priorities:

By supporting continued breeding activity with virus-free plant material, our objectives support the following priorities:

- Develop cultivars that are summer bearing, high yielding, winter hardy, machine-harvestable, disease resistant, virus resistant and have superior processed fruit quality (1)
- Viruses/crumbly fruit, pollination (3)

Objectives:

This is an on-going research effort and all of the following objectives are addressed simulanteously each year:

- Testing field plots at breeding program core research and propagation locations for viruses common in PNW in order to verify clean or infected status.
- Maintaining breeding populations of clean, virus-free plant material to support efficient generation of new breeding families and advanced slections.
- Updated report of virus infection-status and susceptibility following each season.

Procedures: (<400 words)

This is an ongoing project in which foundation plant material and experimental plots located at core breeding program field sites will be screened on a rotating basis for two common pollenvectored viruses, raspberry bushy dwarf virus and strawberry necrotic shock virus, as well as the less common but very damaging tomato ringspot virus (Martin et al., 2013; McMenemy et al., 2012).

The field sites subject to testing will include the primary research farm locations where core germplasm maintenance as well as crossing, propagation, and seedling evaluations occur: the Washington State University Puyallup Research and Extension Center (WSU breeding program), and the Oregon State University Lewis Brown Research Farm and Oregon State University Vegetable Farm (USDA breeding program; Corvallis, OR). Additional field sites subject to testing will include the primary on-farm trial locations for breeding program selections: the Washington machine-harvest trials hosted at Honcoop Farm (Lynden, WA) and the Oregon State University North Willammette Research and Extension Center (OSU-NWREC; Aurora, OR).

Each year, leaf samples will be collected from field plots in spring or early summer for testing. Leaf samples will be ground using a large format Homex homogenizer for ELISA testing or processed on automated system for nucleic acid extractions. For ELISA testing the USDA Virology lab uses a Dynex system which is completely automated. The automated sample processing ensures repeatability and consistency of virus testing. For some viruses nucleic acids will be used to perform virus specific PCR tests.

Each year we will prepare a report summarizing the infection status of field plots and individual selections at core field sites, including information on the location and age of field plots where infection occured and which viruses were present.

Anticipated Benefits and Information Transfer: (<100 words)

Virus-infection status of raspberry breeding selections. Mitigation of virus spread within PNW breeding populations. The breeding programs will continue to develop cultivars and advanced selections with better performance or fruit characteristics than current industry standard varieties, or that will complement the production season of current industry standards. Cultivars and advanced selections will be distributed as virus-free plant material and made available at regional nurseries.

Virus testing results will be summarized in infection-status reports and made available to the industry as annual reports to WRRC and provided upon request.

References

Martin, R.R., MacFarlane, S., Sabanadzovic, S., Quito, D., Poudel, B., and Tzanetakis, I.E. 2013. Viruses and virus diseases of *Rubus*. Plant Disease 97:169-182.

McMenemy, L. S., Hartley, S. E., MacFarlane, S. A., Karley, A. J., Shepherd, T., and Johnson, S. N. 2012. Raspberry viruses manipulate the behaviour of their insect vectors. Entomologia Experimentalis et Applicata, 144:56-68.

Budget:

Amount allocated by Commission for previous year: $ 0

	2023	2024	2025
Salaries[1]	$3,000	$3,000	$3,000
Time-Slip	$	$	$
Operations (goods & services)[2]	$3,000	$3,000	$3,000
Travel	$	$	$
Meetings	$	$	$
Other	$	$	$
Equipment	$	$	$
Benefits	$	$	$
Total	**$6,000**	**$6,000**	**$6,000**

Budget Justification

[1]Laboratory research assistant responsible for sample preparation and analysis

[2]Laboratory supplies and reagents for sample preparation and analysis

Appendix I: Current and Pending Support Table

Current & Pending Support					
Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
Current:					
Peterson, Simons, Kubota, Ramirez, Francis, Teegarden, **Hardigan**, Luby, Bassil	Foundation for Food & Agriculture Reseearch	$1,800,000	09/2023-09/2026	10%	Advancement of Strawberries for Indoor Environments: Mapping Chemical Compositions, Genetics, and Growing Conditions for Premium Flavor
DeVetter, Bryla, **Hardigan**, **Hoashi-Erhardt**	USDA Specialty Crop Multi-State Program	$1,000,000	09/2023/09/2026	10%	Beat the Heat - Mitigating Heat Damage in Caneberry
Hardigan, Luby	USDA-Northwest Center for Small Fruit Research	$50,000	09/2022-09/2023	10%	Evaluating the potential of genetic markers for predicting blueberry fruit quality and ripening season in Pacific Northwest germplasm
Stockwell, Hardigan	USDA-Northwest Center for Small Fruit Research	$98,000	09/2022-09/2024	5%	Assessing the role of Gnomoniopsis idaeicola and other fungal cane blight pathogens in Blackberry Collapse
Hoashi-Erhardt, **Hardigan**, Zasada, Dossett	USDA-Northwest Center for Small Fruit Research	$135,000	09/2023-09/2025	10%	Genomic Prediction for Quantitative Resistance to Root Lesion Nematode in Raspberry
Pending:					

A Report to the Washington Raspberry Commission

Title: Control of Cane Blight in Raspberry

Year Initiated: 2022 **Current Year**: 2022 **Terminating Year**: 2023

Principal Investigator:
Alan Schreiber, 2621 Ringold Road, Eltopia, W 99301, aschreb@centurytel.net
Tom Walters, Walters Ag Research, 2117 Meadows Ln, Anacortes WA 98221 waltersagresearch@frontier.com, 360-420-2776.

Background. A raspberry cane blight project was initiated in 2019 to develop a means to control cane blight. After the first year of research the research site was removed by the grower. This resulted in a entire year set back on the project as the same applications needs to be made to the same plots to both the primocane and the subsequent year's floricane to effectively evaluate the treatment's efficacy. 2021 was the third year of the project and second year of treatments to the same plots. Overall, efficacy results against cane blight were disappointing with only one treatment providing much control. However, use of Velum Prime for cane blight control using timings for nematode control did not provide a great deal of reduction in root lesion nematode numbers.

Justification and Background: Cane blight, which is caused by the fungus *Kalmusia coniothyrium,* occurs on a wide range of crops including raspberry, blackberry and roses, and was only recently recognized as a major pest on Washington red raspberries. Cane blight infection requires a wound, such as those that occur during machine harvest, to infect a plant. Infections commonly originate on primocanes during summer. Shortly after infection the fungus colonizes vascular tissue. The fungus will produce small black pimple-like spore producing bodies in the fall and overwinter on the cane. The fungus will continue to grow in the spring and it will slowly girdle the cane. The girdled cane will start to wilt and collapse during early fruit development. Symptoms will develop quicker during hot and dry weather. Uninfected canes and roots are not affected. The fungus can also live on the dead tissue such as cane stubble or debris in the soil. Cane blight rarely is a problem in hand-harvested fields. Rain or overhead irrigation during harvest has increased disease incidence because spores are disseminated in splashing water. Young canes are more rapidly infected while older canes of raspberry are more resistant to infection in the fall.

Northwest Plant Company cultivars (WakeField, WakeHaven), Driscoll's cultivars and Chemainus appear to have a comparatively high level of sensitivity to this disease. In 2015, older WakeField plantings where cane blight had not been managed had up to 40% yield losses. WakeField represents about 30% of Washington's raspberry acreage and up to 50% of the state production. There are non-chemical control options that can reduce infections including pruning out infected canes, avoiding excess nitrogen, adjusting harvester catcher plates to reduce wounding, leaving cane stubble as short as possible and minimizing humidity during infection periods. However, despite the use of these tactics the disease has become a worsening problem. The primary means of controlling the disease is expected to be fungicides. No other researchers have addressed this issue. Currently, the products recommended for control of cane blight are Tanos (famoxadone (Group 11), cymoxanil (Group 27)) and QuiltXcel (propiconazole (Group 3) and azoxystrobin (Group 11)), although cane blight is not on either label. Tanos requires rotation with fungicides containing different modes of action. The only products registered on caneberries that have cane blight on the label are copper and lime sulfur products (14 total products between the two types of products.) However, lime sulfur cannot be applied in season and copper is not thought to be very effective. One Washington raspberry grower found that alternating Tanos with Switch (Group 9 and 12) and Pristine (Group 7 and 11) seemed to reduce cane blight.

Lisa Jones, a Ph.D. plant pathologist with Northwest Plant Company, has carried out field and laboratory investigations on cane blight including the first identification of the disease on Wakefield raspberry in 2015. She has conducted lab bioassays screening selected fungicides against cane blight and found that Switch and Pristine were the most effective, with Kenja (isofetamid (Group7)) and Tanos being intermediate in effectiveness and Decree (fenhexamid (Group 17)) and PhD (polyoxin D) were relatively ineffective. A concern with applications of these products is that they occur during timings for *Botrytis*. Applications of products like Switch and Pristine have implications for resistance management. Drs. Jones, Walters and I propose to screen various fungicide use patterns for their ability to control cane blight in bearing raspberries in addition to collecting biological information on this disease. In 2021, this effort was expanded to include efficacy of Velum Prime against root lesion nematodes. This will be expanded in 2022. This is the only research being conducted against this disease on raspberries in the United States.

Materials and Methods

Following the 2021 trial, a raspberry cane blight trial was conducted in August 2022 by Agricultural Development Group, Inc. about 6 miles south of Lynden, WA to further evaluate the effect of Velum Prime on raspberry cane blight, in comparison with multiple industry standards (Table 1). The trial was conducted in the exact location as in 2021 with the same treatments on the same plots. The experimental design was a RCB with 4 replications with the plot size of 10 ft x 30 ft. Applications A and B for this trial were made via drip with the A timing being 1 month pre harvest on July-1 and B timing being 1 days before harvest on Aug-1. The rest of the applications CDEF for this trial were made by an over the row sprayer (Photo 1) to apply treatment spray at 35 gallons/acre during harvest. Both sides of each plot's raspberries were simultaneously sprayed to ensure complete coverage with the experimental products used. The rows of raspberries established for this trial were not treated with any maintenance fungicides to prevent the possibility of interfering with the existing trial's objectives. The raspberry variety is Wakefield, a variety with known susceptibility to the disease.

The number of infected floricanes that collapsed in 50 random floricanes was evaluated on Sep-16 (Photo 2). The number of infected primocanes out of 50 primocanes were counted on Nov-21. Then the % incidence for floricane and primocane infections was calculated using infected canes divided by the 50 x 100%.

Results and Discussion

Similar to 2021 trial, we thought Velum Prime may have some impact on root-lesion nematode, we have collected soil samples for nematode analysis for the Velum Prime and the untreated check. The samples were sent to the same USDA lab in Corvallis, Oregon (Dr. Inga Zasada). We are still waiting for the result and will update it as soon as possible.

Miravas was the only treatment that statistically reduced the floricane cane blight infection incidence at 13.5%, compared to the 22.5% of untreated (Table 2). This is the second year where Miravas was the most effective product for control of cane blight. None of the treatments impacted primocane infection incidence.

At this point, we recommend use of Miarvas for cane blight. This product is a FRAC Group 7. Its use for control of cane blight has implications for botrytis resistance management. Use of this product for cane blight has to count towards applications of FRAC Group 7 fungicides. Our recommendations is to use Miravas during harvest time to target cane blight and botrytis but after two applications, the applicator must rotate to a different mode of action.

Table 1. Treatment list and application timings.

Trt No.	Treatment Name	Form Conc	Form Type	Rate	Rate Unit	Appl Code	Amt Product to Measure	Rep 1	2	3	4
1	Untreated check							102	203	307	409
2	Velum Prime	500	L	237.5	g ai/ha	A	6.364 mL/mx	107	201	303	410
3	Velum Prime	500	L	237.5	g ai/ha	AB	6.364 mL/mx	110	208	301	406
4	Kenja		L	15.5	fl oz/a	CDEF	15.15 mL/mx	108	204	305	403
5	Luna Tranquility		L	16.42	fl oz/a	CDEF	16.05 mL/mx	105	206	310	405
6	Switch		SG	14	oz/a	CDEF	13.12 g/mx	101	202	306	404
7	Elevate 50 WDG		WDG	1.5	lb/a	CDEF	22.49 g/mx	103	210	309	401
8	Tanos 50 DF		SG	10	oz/a	CDEF	9.372 g/mx	104	205	304	407
9	Actigard		SG	0.75	oz/a	CDEF	0.7029 g/mx	109	207	308	402
10	Miravas		L	10.3	fl oz/a	CDEF	10.07 mL/mx	106	209	302	408

Application Description

	A	B	C	D	E	F
Application Date	7/21/2022	8/1/2022	8/5/2022	8/12/2022	8/19/2022	8/26/2022
Application Method	SPRAY	SPRAY	SPRAY	SPRAY	SPRAY	SPRAY
Application Placement	FOLIAR	FOLIAR	FOLIAR	FOLIAR	FOLIAR	FOLIAR

Table 2. ANOVA table for floricane and primocane infection incidence.

Pest Name					Cane Blight of >	Cane Blight of >
Crop Name					wild raspberry	wild raspberry
Rating Date					9/16/2022	11/21/2022
SE Description					Floricane	Primocane
Rating Type					PESINC	PESINC
Rating Unit/Min/Max					%, 0, 100	%, 0, 100
Sample Size					50 canes	50 canes
Reporting Basis					1 plot	1 plot
Trt-Eval Interval					46 DA-A	46 DA-A
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	1*	2*
1	Untreated check				22.5a	14.0a
2	Velum Prime	237.5	g ai/ha	A	22.5a	12.5a
3	Velum Prime	237.5	g ai/ha	AB	22.5a	15.0a
4	Kenja	15.5	fl oz/a	CDEF	23.5a	15.5a
5	Luna Tranquility	16.42	fl oz/a	CDEF	23.0a	17.5a
6	Switch	14	oz/a	CDEF	26.0a	18.0a
7	Elevate 50 WDG	1.5	lb/a	CDEF	24.0a	14.0a
8	Tanos 50 DF	10	oz/a	CDEF	26.0a	15.5a
9	Actigard	0.75	oz/a	CDEF	25.0a	17.5a
10	Miravas	10.3	fl oz/a	CDEF	13.5b	14.0a
LSD P=.10					5.35	6.87
Standard Deviation					4.44	5.70
CV					19.45	37.16
Replicate F					10.297	0.781
Replicate Prob(F)					0.0001	0.5146
Treatment F					2.567	0.410
Treatment Prob(F)					0.0281	0.9186

Photo 1. Foliar application using over the row sprayer.

Photo 2. Cane blight lesions on Sep-16.

2023 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

New Project Proposal **Proposed Duration:** 2 years

Project Title: Extending the lifetime of plantings with novel post-plant nematicides

PI:
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Co-PI:
Inga Zasada
Research Plant Pathologist
USDA-ARS HCRL
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Cooperators:

Year Initiated 2023 Current Year 2023 Terminating Year 2024

Total Project Request: Year 1 $6,445 Year 2 $6,445 Year 3 $

Other funding sources: in-kind. Product and consultation provided by registrants.

Description:
Root lesion nematodes weaken raspberry plantings, reducing their productive lifetime. Replanting is expensive and leaves a field out of production for 1-2 years, so increasing a planting's lifetime has a large economic effect. Current treatments for root lesion nematodes focus on preplant soil fumigation, and the option to apply oxamyl to newly planted fields only. No proven effective measures are available for plantings during their productive years.

We propose to evaluate two new products with known nematicidal activity. Velum Prime (active ingredient fluopyram) is labeled for nematode control on caneberry, and preliminary results suggest it can be effective. Reklemel (active ingredient fluazindolazine) has activity on a wide range of nematodes, and is considered a promising product for this application. We will evaluate both products' impacts on root lesion nematode populations in a raspberry field with substantial root lesion nematode populations.

Justification and Background:
The root lesion nematode *Pratylenchus penetrans* commonly feeds on raspberries and on many other crops in western Washington soils. High populations damage raspberries and can reduce yield to economically non-viable levels. *P. penetrans* control in raspberry largely relies on preplant measures such as soil fumigation and rotation to other crops (such as seed potato) in which Vydate (oxamyl) can be used to reduce *P. penetrans* populations. In addition, Washington has a special local needs label allowing Vydate application to raspberry up to 1 year prior to harvest. Thus, plantings can be treated through June of the planting year. However, after this point, there are no proven postplant control measures for this pest for the remaining 5-10 years of the planting's lifetime. A reliable postplant control measure could have a large economic benefit to growers if it would allow plantings to remain economically viable for longer.

Furthermore, new nematode control measures need to be less disruptive to other organisms to be safer to use, to integrate with biocontrol measures and to maintain soil health. Three new nematicides, fluensulfone, fluopyram and fluazindolazine appear to meet these needs (Deseager et al, 2020). All are much safer to use than their earlier counterparts.

We tested Fluensulfone (Nimitz) in raspberry previously, but it was not effective. On the other hand, fluopyram (Velum Prime) did show good *P. penetrans* control in British Columbia (E. Gerbrant, personal communication). In addition, we found encouraging preliminary data from Whatcom county in 2021: A WRRC-sponsored trial of cane blight control included two drip-applied Velum Prime treatments: 6.5 fl oz applied either 30 days prior to first harvest, or applied 30 and 3 days prior to first harvest. Luckily for us, the trial area was moderately infested with *P. penetrans*. The Velum Prime treatments significantly reduced root *P. penetrans* populations the following October (table below).

Treatment	***P. penetrans*/g root pretreatment**	***P. penetrans*/g root October**
Untreated check	166	717
Velum 1x	134	17
Velum 2x	560	15

The third new nematicide, fluazindolazine, has shown activity on many plant parasitic nematodes in other systems, and will be labeled by Corteva as Reklemel. Although *P. penetrans* is not a primary target of this nematicide, Corteva is supportive of this research, and willing to lend expertise and product. We want to learn whether we can reliably use either or both of these products for postplant *P. penetrans* control in raspberry.

Relationship to WRRC Research Priority(s):
This project relates to "Understanding soil ecology (*including biology, nutrient balance*) and soil borne pathogens and their effects on plant health and crop yields."

Objectives:
The research in year 1 will establish whether these treatments can reduce *P. penetrans* population densities with a single year's treatment. Depending upon first year's results, we plan to repeat the treatments the following year in this or another field.

Procedures:
This project is anticipated to take two years. A cooperating grower will identify a field with significant *P. penetrans* populations but not slated for replacement for at least two years. Pretreatment root and soil samples will be collected May, 2022. Plots will be randomized and laid out, with four replicate plots/treatment and each plot 10 x 30-60 ft long. First treatments will be applied early June 2022. Additional treatments will be applied early July and early September, according to the table below. Reklemel will be applied at 2 lb a.i./a, and Velum Prime will be applied at 6.84 fl oz/a. Products will be applied through drip line, applying approximately 0.25-0.5 inches of water to the beds.

Treatment	Product	Application	Sampling
1	UTC		July, August, September
2	Reklemel	June	July, September
3	Reklemel	September	July, September

4	Reklemel	June, September	July, September
5	Reklemel+Velum Prime	June	July, September
6	Velum Prime	June	July, August, September
7	Velum Prime	June, July	July, August, September

Samples for nematode analysis will be collected approximately 1 month after treatment, also according to the table. Samples will be processed in the Zasada lab at USDA-HCRL Corvallis, producing results based on *P. penetrans*/g fresh weight of roots. Treatments will be considered effective if they reduce *P. penetrans* populations one month or more after treatment, and treatments will be continued for a second year, depending upon first year results.

Anticipated Benefits and Information Transfer:

- Growers will gain data on the effectiveness of labeled, but costly Velum Prime applications for managing root lesion nematodes in infested fields.
- Preliminary data on Reklemel may result in a label for use on caneberry.
- Information will be passed on to growers through the Small Fruit Update, and through presentations at the Small Fruit Conference in Lynden.

References:

Desaeger J, Wram C, Zasada I. 2020. New reduced-risk agricultural nematicides – rationale and review. J. Nematology 52: 1-16

Budget: *<u>Indirect or overhead costs are not allowed</u>* unless specifically authorized by the Board

	2023	2024	2025
Salaries[1/]	$3,500	$3,500	$
Time-Slip	$ 500	$ 500	$
Operations (goods & services)	$1,500	$1,500	$
Travel[2/]	$ 345	$ 345	$
Meetings	$	$	$
Other[3/]	$ 600	$ 600	$
Equipment	$	$	$
Benefits[4/]	$	$	$
Total	**$6,445**	**$6,445**	**$**

Budget Justification

[1/] Walters, 0.035% FTE, benefits included.

[2/]5 trips Anacortes to Lynden, 120 miles/trip, $0.575/mile

[3/]Supplies (drip tape, fittings) $300. Shipping for samples, $300.

[4/]Included here are tuition, medical aid, and health insurance for Graduate Research Assistants, as well as regular benefits for salaries and time-slip employees.

Washington Red Raspberry Commission
Progress Report Format for 2022 Projects

Project No: 22PN025

Title: Characterization of Botrytis spp on red raspberries in Northwestern Washington

Personnel:

Virginia Stockwell (P.I. USDA-ARS)
Jeff DeLong (Co-P.I USDA-ARS)
Chakradhar Mattupalli (Cooperator WSU)

Reporting Period: 2021-2022

Accomplishments:

Botrytis is a "high risk" pathogen for the development of fungicide resistance. This is due to its inherent genetic diversity, and rapid production of millions of spores. Unfortunately, some of the main tools we have for management of this pathogen select for persistence of fungicide resistant variants. This is a non-sustainable, particularly when resistance to multiple fungicide chemistries is becoming commonly observed.
Overall, we can't afford to spray materials 'blindly' or not knowing how these fungicide applications are affecting the pathogen populations over time.

Our approach to resolve this issue is to better understand how Botrytis is reacting to and surviving management strategies. We want to define the existing in-field Botrytis populations both in genetic structure and fungicide resistance phenotypes, much like determining a family tree for each field. We especially need to understand how or when different lineages appear and how fungicide resistance patterns change.

By understanding the biological system of the pathogen, we can develop better practical disease management strategy. For raspberry growers, this means targeted, spray programs that are not only more cost-effective, but a reduction and mitigation in *Botrytis* disease pressure.

- We collected *Botrytis* samples from 12 spatially isolated, conventionally managed, red raspberry fields within Whatcom County. From each field we collected at three time points throughout the 2022 season. We collected mid-February, designated as Overwintering or early season phase, mid-May designated as mid-season, and early August around harvest, or late season phase. Multiple host tissue types were collected from each site, and a randomized in a row- collection pattern across each entire field was used for sampling.
- Spore rod traps were constructed and deployed into 5 cooperating field sites. Rods were collected twice a week during the growing season.
- A *Botrytis* samples collected were single spored, and DNA has been extracted.
- Optimization of a growth assay for screening isolates to fungicide sensitivities, is currently ongoing.
- SSR screening for informative population markers has begun on a subset of 2022 *Botrytis* samples collected.

Results:

- 485 pure cultures of *Botrytis* samples collected. All samples have been single spored, processed for DNA extractions, DNA quantified, and isolate tissue prepared and stored at -20C for future use.
- Microsatellite markers for genotyping have been eluted and DNA for a subset of 95 isolates representing all twelve fields, for all three time points have been screened against two of sixteen population markers BC_POP4 and BC_POP5.
- Spore rods were collected bi-weekly and have been preserved at -80C. DNA extractions and qPCR screening to quantify will begin early 2023.
- Microplate reader was purchased and assays currently undergoing optimization, for screening against pre-determined discriminatory doses of fungicides.

2023 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

Project Continuance Proposal **Proposed Duration:** (3 yr -original request)

Project Title: Characterization of *Botrytis* spp. on red raspberries in Northwestern Washington.

PI: Virginia Stockwell, USDA-ARS Research Plant Pathologist, 3420 NW Orchard Ave., Corvallis, OR 97330, Virginia.stockwell@usda.gov, 541-738-4078

Co-PI: Jeff DeLong, USDA-ARS Supporting Scientist, 16650 WA-536, Mt Vernon, WA 98273, Jeff.delong@usda.gov, 360-848-6134

Cooperator: Chakradhar Mattupalli, Assistant Professor, WSU Mount Vernon NWREC, 16650 WA-536, Mt Vernon, WA 98273, c.mattupalli@wsu.edu, 360-848-6138

Year Initiated 2022 Current Year 2022 Terminating Year 2024

Total Project Request: Year 1 $20,000 Year 2 $3,000 Year 3 $

Other funding sources: None (Previously, requested a no-cost extension from WSCPR)

Notes:

We are diligently continuing to work on this research project. We are grateful for the current funding we have received which enables us to conduct the work.

To the point of funding requests for FY23, we earnestly assessed our financial requirements to complete the project, or at least address most of the objectives within the upcoming year. We honestly felt with the funds received we are in good standing to meet these objectives, but we may be cutting it close. That being the main reason we elected to request a no-cost extension with the WSCPR.

However, to ensure we don't operate in a deficit should unforeseen circumstances or supplies shortages occur we are requesting WRRC would consider providing additional funding for FY23 without the matched contributions from the WSCPR.

Description:

The long-term objective of this project is to improve management of *Botrytis* fruit rot and gray mold in Washington Red Raspberries. Application of synthetic fungicide sprays are the primary management strategy for control of gray mold on raspberries. Due to the high incidence of previously observed in-field fungicide resistance occurrences, this research would be important to monitor and characterize the pathogen's long-term genetic stability as it evolves to environmental and synthetic spray applications.

Justification and Background:

Botrytis cinerea, the causal agent of fruit rot and gray mold, results in serious losses from pre- and postharvest diseases in over 200 economically important crop hosts worldwide (11). Infection of raspberry flowers and berries can directly reduce yield and berry quality (2, 6, 8) in all locations where red raspberries are grown, including British Columbia, Idaho, Oregon, and Washington.

Botrytis is a "high risk" pathogen for the development of fungicide resistance owing to its rapid lifecycle, genetic diversity, high fecundity (production of millions of spores), and spread by wind (1, 4, 5, 10). Resistance to several fungicide classes defined by Fungicide Resistance

Action Committee (FRAC), including demethylation inhibitors (DMIs, FRAC 3), succinate dehydrogenase inhibitors (SDHIs, FRAC 7), and quinone outside inhibitors (QoIs, FRAC 11) has been reported worldwide (4, 12, 17, 18). The increasing prevalence of fungicide resistance in *Botrytis* has become a serious limitation for effective disease control. An increasing number of isolates with resistance to not only a single fungicide but also to multiple fungicides of different chemical classes have been reported (3, 9, 15). Fungicide resistance frequencies have been shown to differ between years, crop hosts, locations, and among different strains of *Botrytis* spp. (3, 10). Genetic variability of *Botrytis* isolates within a population may influence the development of fungicide resistance, it is also likely that environmental variation (i.e…locations, hosts, synthetic spray applications) are an important driver for observed and persistent fungicide resistance. Because different *Botrytis* spp. can exhibit differences in fungicide resistance profiles, it is critical to understand the pathogen population structure in different environments. The characterization of both fungicide resistance profiles and linking these profiles to genetic diversity among populations will allow development of better disease management strategies. There is limited information about *Botrytis* ssp. population structure and genetic diversity in red raspberry fields from Washington and understanding adaption to the host is a key issue for "generalist" pathogens, like *Botrytis*, particularly as it relates to disease management. The research addressed in this proposal focuses on using microsatellite markers, to investigate the genetic diversity of *Botrytis* spp. and fungicide resistance status currently existing in the northwestern Washington red raspberry fields. By observing changes in the population structure as it relates to fungicide resistance, we are able to monitor pathogen stability in-fields in response and adaption to different environments.

Relationship to WRRC Research Priority(s):

Priority group #2 "Fruit rot, including pre-harvest, postharvest, and/or shelf life"

Objectives:

We hypothesize, that *Botrytis* spp. population structures in Washington red raspberry fields are evolving. The objectives of this research are to profile fungicide resistance and genetic diversity of *Botrytis* spp. in red raspberry fields of northwestern Washington.

Funding for 2023 will address: collection of *Botrytis* samples from fields; pure culture production; fungicide sensitivity assays; genotyping assays

Procedures:

We will continue to sample twelve conventionally managed red raspberry fields in Whatcom County as conducted in 2022. Manual sampling of cane, flower, or ripe berries will be conducted at three time points throughout the season. The spore traps with impaction rods will be placed in red raspberry fields and serviced and monitored routinely throughout the entire growing season and removed during the winter months. Manually collected *Botrytis* samples will be transferred to PDA, and single spored to obtain pure cultures. *Botrytis* conidia collected from the spore trap impaction rods will be subjected to DNA extractions. Fungal stock cultures will be made and stored at -80°C until further use.

Pure fungal stock cultures continue to be assessed in a modified broth assay (13,14,16) to determine fungicide sensitivity based on relative turbidity. Briefly, technical grade fungicides containing a single active ingredient and belonging to multiple FRAC groups, are suspended in acetone at 10,000 μg/ml. For each isolate, multiple spore suspensions (1×10^3) in 2% malt extract broth are aliquoted into clear, flat-bottomed, 96-well reaction plates. Pre-established discriminatory dose concentrations of each fungicide (i.e., 1, 50, and 100 ppm) are added in duplicate to screen isolates against each fungicide and dose concentration. A Tecan Infinite Pro 200 microplate reader measures absorbance at 405nm (0 and 48 hrs at 22-24^{o}C) and used to assess conidial germination growth for each reaction condition.

Specifically, we will test sensitivity to at least the following fungicides and associated

FRAC classes: myclobutanil and prothioconazole (FRAC3), boscalid, fluopyram, isofetamid - “Kenja”, and, fluxapyroxad (FRAC7), cyprodinil and pyrimethanil (FRAC9), and trifloxystroblin (FRAC11), and compare efficacy of common mix sprays such as Luna Tranquility and Luna Sensation. Salicylhydroximic acid (SHAM) will be added to media to inhibit the pathogen’s alternative oxidase pathway when testing for resistance to FRAC 11.

Nine previously developed polymorphic microsatellite makers (3) will be used to assess allelic differences in *Botrytis* isolates. PCR amplicons will be subjected to fragment analysis and processed at the USDA-ARS HCRU in Corvallis, OR. Allele fragment size data will be analyzed using computer software *Geneious*. Population analysis and genetic diversity will be calculated using *Poppr* with in RStudio. Pairwise population genetic identify among and between populations based on location and fungicide resistant frequencies will be calculated using the software *GenAlEx.*

Project will span approximately 2 yrs.
2023- Collection of Botrytis samples and spore rods, fungicide sensitivity assays PCR, Fragment analysis
2024- Genetic diversity and population data analysis

Anticipated Benefits and Information Transfer:

Understanding the presence and quantity of the pathogen is required to predict disease risk successfully during the growing season. This research will provide a baseline of the inoculum pressure in the field, adding to our model predicting knowledge abilities. Further, analysis of the existing *B. cinerea* population structures within fields will help to identify existing fungicide resistance profiles occurring in Washington raspberry crops. Relating the observed disease pressure incidences with resistance phenotypes will help with an effective field-specific disease management strategy. Further, this research aims to explore new techniques that will allow for the development of a high throughput screening protocol for fungicide resistance.

References:

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Budget: *Indirect or overhead costs are not allowed* unless specifically authorized by the Board

	2023	2024	2025
Salaries[1/]	$0	$	$
Time-Slip	$0	$	$
Operations (goods & services)	$3,000	$	$
Travel[2/]	$0	$	$
Meetings	$0	$	$
Other	$0	$	$
Equipment[3/]	$0	$	$
Benefits[4/]	$0	$	$
Total	**$3,000**	**$**	**$**

Budget Justification
Fund request will cover molecular assay consumables and processing service fees associated with genotyping through the Center for Quantitative Life Sciences (CLQS) at Oregon State University , Corvallis OR.

SOILS

Washington Red Raspberry Commission
Progress Report Format for 2022 Projects

Project No: 142522

Title: Where do we go from here? Application of soil health concepts to red raspberry production

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Reporting Period: 2022

- An "EcoRaz II" meeting was organized and held in Everson in April 2022. This one-day meeting brought together researchers, consultants/outreach specialists, industry representatives, administrators, and government officials (i.e., Shewmake) to discuss, learn, and create a strategic vision on key soil health issues in Washington raspberry systems. Strategies to address soil health issues were also discussed and centered around the creation of a long-term experimental site in Whatcom County that would allow for research on soil health and synergistically also support plant breeding efforts critical for the industry. Outcomes of this meeting included increased industry knowledge of soil health, greater awareness among researchers on key issues, and a vison on how to pursue external funding independent of the commission that would allow long-term research on soil health through government funding.
- A short presentation and follow-up survey on soil health priorities was held at the Washington Red Raspberry Machine Harvest Field Day in July 2022.
- Multiple meetings were held with growers to review and discuss soil health concerns and feasible ways to address them.
- A chapter on soil health was written, reviewed and revised after industry input, and submitted for inclusion in the Washington Soil Health Roadmap Guide. This roadmap outlines the current situation of soil health in Washington State, identify goals and milestones looking forward, and establishes detailed plans to maintain and improve soil health. Inclusion of raspberries in this guide is essential in showing the need and moving forward with requesting funds for long-term soil health research for raspberry in Whatcom County and was the path to secure funds for current long-term soil health research projects in potato, grape, etc.

Accomplishments:

- Key soil health issues for raspberry production in Whatcom County were identified.
- Knowledge on soil health was improved.
- A path towards securing research for long-term soil health research was identified with significant interest and support demonstrated from local government (Shewmake).
- A chapter on soil health was written, revised, and submitted for inclusion in the official Washington Soil Health Roadmap Guide.
- The raspberry industry has been catalyzed to cooperatively find a path to secure funding for long-term soil health research that is executed synergistically with plant breeding efforts in Whatcom County. It is essential that this effort occur in Whatcom Country given the concentration of the industry in this particular county.

Results:

Soil fertility, compaction, and soilborne pathogen and nematode management were identified as key soil health concerns by growers and crop advisors. Viable solutions are yet to be identified and necessitate long-term research. The industry is interested in long-term soil health research. The industry is now positioned to purse efforts to secure long-term funding for soil health research through the Washington legislator. Researchers in the region are ready to provide additional information to the WA red raspberry industry to help support their effort.

Publications:

Benedict, C., L.W. DeVetter, D. Griffin LaHue, T. Walters, and I. Zasada. 2022. Red Raspberry. In: Washington State Soil Road Map. Available at: https://soilhealth.wsu.edu/washington-state-soil-health-roadmap/. This chapter is in press.