WASHINGTON
AMERICA'S RASPBERRIES

2025 Research Proposals

and

2024 Research Reports

WASHINGTON Red Raspberries

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

Year	Seat	
27	1	John Clark Lynden
25	2	Andy Enfield Lynden
26	3	Mark Van Mersbergen, Pres. Lynden
23	4	*OPEN*
27	5	Brad Rader Lynden
25	6	Matt Maberry Lynden
WSDA	7	Dani Gelardi, WSDA Olympia

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2025 Research Priorities

#1 priorities

- Labor saving practices – ex. Pruning efficiency, public/private technology partnerships, harvester automation
- 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
- Foliar & Cane diseases – i.e. spur blight, yellow rust, cane blight, powdery mildew

#2 priorities

- Fruit rot including pre harvest, post-harvest, and/or shelf life
- Understanding soil ecology (*including biology, nutrient balance*) and soil borne pathogens and their effects on plant health and crop yields.
- Cutworm, leafroller management
- Soil fumigation techniques and alternatives to control soil pathogens, nematodes (dagger), and weeds
- Irrigation management – application techniques including pulsing

#3 priorities

- Thrips – understand the lifecycle, and control strategies
- Snail control – understand lifecycle and management strategies
- Root weevils
- Alternative Management Systems – fruit yield per linear foot of bed – planting densities, row spacing, trellising
- Nutrient Management – Revise OSU specs, timing, varieties, appl. Techniques, calcium, nutrient balance
- 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

2025 WRRC Research Budget

PAGE	PROJECT TITLE	RESEARCHER (S)	REQUEST	DRAFT 1	Other $	Source	Approved
PLANT BREEDING			100.00%	#DIV/0!			#DIV/0!
5	Red Raspberry Breeding, Genetics and Clone Evaluation	Hoashi-Erhardt	$80,801			NWCSFR	
16	Coordinated Regional on-farm Trials	NWBF - Walters	$5,296			in-kind	
23	Red Raspberry Cultivar Development	Dossett	$10,000		$872,988	Ag Canada	
29	Cooperative raspberry testing and cultivar development	Hardigan	$7,000			ORBC	
39	Virus Testing of PNW raspberry breeding programs	Hardigan	$6,000				
	WRRC Land and Management fees		$75,000				
ENTOMOLOGY			30.11%	#DIV/0!			#DIV/0!
47	Two-Spotted Spider Mites and Thrips in Red Raspberries	Schreiber	$15,000		$28,000	WSCPR	
59	Spotted Wing Drosophila Control with Sterile Insect Releases	Nottingham	$13,988		$21,155	WSCPR	
65	Monitoring Raspberry SWD Populations for Insecticide Resistance	Schreiber	$10,000				
68	Management of Snails	Schreiber					
WEEDS			16.81%	#DIV/0!			#DIV/0!
74	Management of weeds in the *Polygonaceae* family	Benedict	$9,272		$9,612	WSCPR	
86	New Technology, Products for Raspberry Weed Management	Schreiber	$12,495			WSCPR	
PHYSIOLOGY			15.00%	#DIV/0!			#DIV/0!
94	Calcium accumulation and increasing fruit uptake	DeVetter				NWCSFR	
96	Determining Leaf Nutrient Sufficiency Standards	DeVetter	$19,428				
PATHOLOGY/VIROLOGY			38.08%	#DIV/0!			#DIV/0!
101	Control of Cane Blight in Red Raspberries	Schreiber	$15,000		$18,000	WSCPR	
113	Characterization of Botrytis on red raspberries	Stockwell/DeLong					
117	Extending the lifetime of plantings with novel post-plant nematicides	Walters	*extension*				
124	Managing Cane Botrytis of Raspberry	Schreiber	$17,142				
127	Managing Fungicidally Resistance Gray Mold in Raspberries	Schreiber	$17,160				
SOILS							
	Total Plant Breeding		**$184,097**	**$0**			**$0**
	Total Production Research		**$129,485**	**$0**			**$0**
	Research Related	WRRC expenses	$3,000	$3,000			
	Small Fruit Center fee		$3,000	$3,000			
	TOTAL		**$319,582**	**$6,000**			**$0**
	2025 Plant Breeding Budget		$200,000	$200,000	report only	applied N/F	
		under budget	$15,903	$200,000			
	2025 Research Budget		$115,000	$115,000			
		under budget	-$20,485	$109,000			

PLANT BREEDING

Project: 13C-3755-5641
TITLE: Red Raspberry Breeding, Genetics, and Clone Evaluation
PROJECT LEADER:

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

Reporting Period: 2024

Objectives:
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.

Accomplishments:

Cultivars and prospective cultivars.
WSU 2188 ('Cascade Legacy') is a new cultivar of red raspberry with large fruit, good firmness, and good flavor. Its season is comparable with 'Meeker'. It has 'patent pending" status. The *HortScience* cultivar release information is ready to be sent to reviewers and for publication. It is being propagated under a nonexclusive license.

WSU 2029 ('Cascade Prize') is a new cultivar of red raspberry that has medium large, firm, bright red fruit with good flavor; exceptionally late harvest season, and exceptional tolerance to *Phytophthora rubi* (Man in 't Veld, 2007) in field trials. WSU 2029 is well suited to fresh production in the PNW and in other regions, has "PVP pending" status, and is being propagated under a nonexclusive license.

WSU 1605 ('Cascade Gem') has "PVP pending" status and is being marketed under a nonexclusive license in North America. 'Cascade Gem' is a fresh production cultivar with large fruit size, high yields, and excellent fruit quality. It performs well for long-cane production.

Crosses, seedlings, and selections.
New crosses were performed in 2024 between parents with traits of excellent machine-harvested yield, berry firmness, and root rot tolerance. Fifty-two crosses were successful out of 56. The seeds have been germinated in vitro and transferred to the greenhouse for development into nursery plugs for further tests with a grower-cooperator in Lynden. Approximately 4,000 seedlings are expected to go out from this year's crosses.

There are 3 seedling fields currently in the ground and being maintained for evaluation, as described in Table 1:

Table 1. Description of seedling fields and activities completed in 2024.

Establish-ment year	Number of seedlings	Activities in 2024
2022	~500	Selections were made from this planting, propagated, and moved. The planting is being removed for cover cropping and rotation.
2023	4000	3600 seedlings were planted in Lynden with a grower cooperator, 400 seedlings were planted at the WSU Puyallup Research and Extension Center (PREC) that the cooperator didn't have room for.
2024	1739	1739 seedlings were planted in Lynden with a grower cooperator and grown according to commercial practices.

Machine Harvesting (MH) Trials - Observational. A new machine harvesting trial was planted in 2024 at Rader Farms. Two other machine-harvesting trials were maintained and evaluated for yield and fruit quality during the 2024 reporting year as indicated in Table 2 below.

Table 2. Description of machine harvest trials and achievements.

Establish-ment year	Number of selections	Achievements
2021	84 and 3 cultivars	Maintained and harvested; This planting was evaluated for a second season in 2024 and is being removed.
2022	75 WSU + 14 ORUS selections, 3 cultivars	Planting was grown according to commercial practices and harvested by machine in 2024. It will be evaluated for a second season in 2025.
2023	39 and 3 cultivars	Prepared, planted and maintained. This planting will be harvested for yield in 2025 and 2026.
2024	46 and 3 cultivars	Prepared, planted and maintained. This planting will be harvested for yield in 2026 and 2027.

The 2021 MH trial was evaluated for the second time in 2024. Several selections stood out for outstanding qualities of plant durability, yield, and fruit quality.

- Cultivars: 'Cascade Harvest' yielded 7.3 T/acre and 'Meeker' had 5.4 T/A.
- WSU 2425 has excellent yield potential, but its fruit is too soft for industry needs. It will be used as a parent in future crosses.
- WSU 2087 is discussed in the replicated yield trial section.
- WSU 2638 yielded 7.4 T/A and gave machine harvested fruit with medium size, good shape and color, and few disease symptoms.
- WSU 2689 yielded 6.4 T/A and had well-shaped, firm machine harvested fruit in the mid-late season.
- WSU 2724 yielded 6.5 T/A and had nice, intact machine harvested fruit with an even collar and a tight drupelet structure.

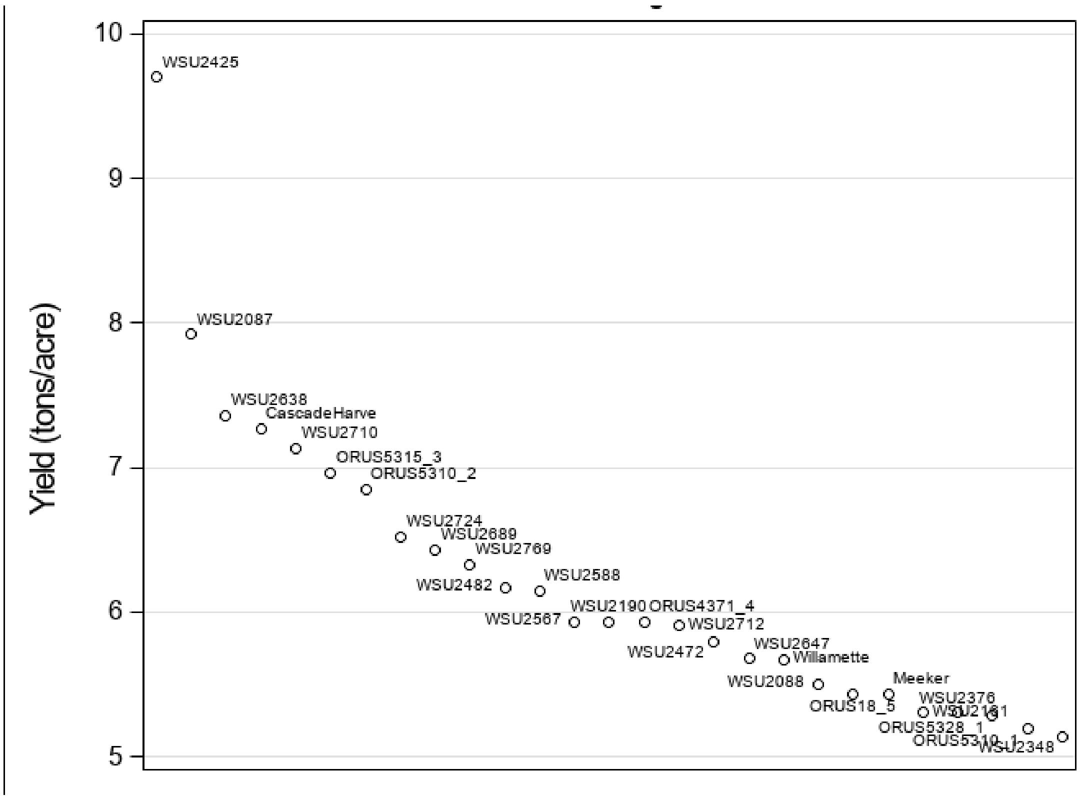

Fig. 1. Yield in tons per acre in 2024 of 27 top-yielding (at least 5.0 tons/acre) selections in nonreplicated plots in the machine harvesting trial established in 2021.

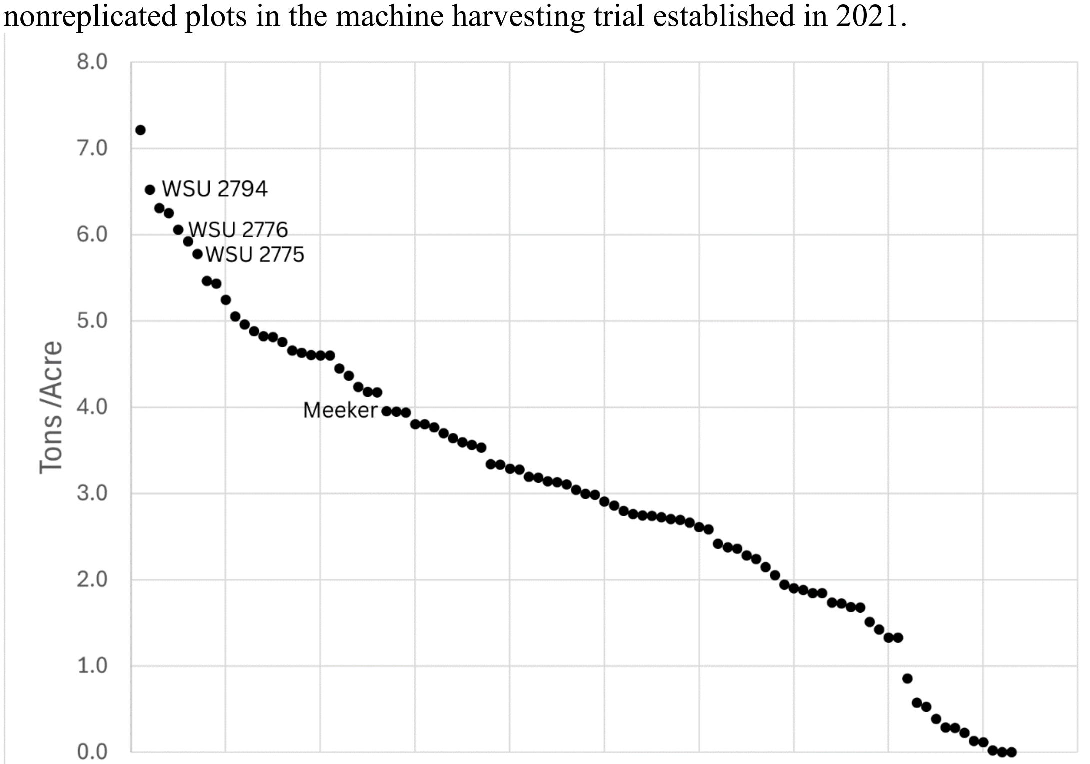

Fig 2. Yield in tons per acre in 2024 of selections in nonreplicated plots in the machine harvesting trial established in 2022.

The 2022 MH trial was evaluated for the first time in 2024. Several selections stood out for outstanding qualities of plant durability, yield, and fruit quality.

- Cultivars: 'Meeker' yielded 3.95 T/A.
- WSU 2794 yielded 6.52 T/A and gave machine harvested fruit that were firm, large, with good flavor, late season, and maintained good shape.
- WSU 2776 yielded 6.25 T/A and had well-shaped, early mid-season, dark red fruit. This selection will need to be watched for softness.
- WSU 2775 yielded 5.78 T/A with fruit of good shape and size in the mid-late season.

Yield and Fruit Quality Evaluations (selection trials). A new yield and fruit quality trial was planted in 2024 at Rader Farms. Two other yield trials were were maintained and evaluated for yield and fruit quality during the reporting year 2024 as indicated in the table below.

Table 3. Description of selection trials and achievements.

Establish-ment year	Number of selections	Achievements
2021	19 and 4 cultivars; 3 replicates	Maintained and harvested; evaluated selections for the second season for fruit quality and yield to drive advancement and discard decisions. This planting will be removed in late fall 2024.
2022	8 and 3 cultivars; 3 replicates	Planting was produced in commercial conditions and evaluated for the first season in 2024. It will be maintained and evaluated for a second season in 2025.
2023	3 and 3 cultivars; 3 replicates	Planting was produced in commercial conditions and will be evaluated for the first season in 2025.
2024	3 and 3 cultivars; 3 replicates	Prepared, planted and maintained. This planting will be harvested for yield in 2026 and 2027.

The selections were harvested for yield 3 times weekly (Table 4). WSU 2069, WSU 2087, and WSU 2068 continued to have excellent yield, fruit quality, and overall good disease and pest tolerance. These three selections are being advanced for potential commercialization.

Table 4. Yield over two years of eighteen WSU selections and three standard cultivars planted in 2021 and harvested by machine.

	Yield[z]			
Clone	2023		2024	
WSU 2069	6.45	bc[y]	9.13	a
WSU 2087	7.28	ab	8.98	a
WSU 2068	5.76	cd	8.41	a
Cascade Harvest	6.24	c	6.84	b
WSU 2425	5.06	de	6.81	b
WSU 2564	7.96	a	6.67	b
Meeker	6.32	bc	6.08	b
WSU 2472	4.41	ef	5.97	bc

WSU 2376	4.22	ef	5.84	bcd
Willamette	3.57	f	5.80	bcde
WSU 2348	5.71	cd	5.61	bcdef
Cascade Premier	3.47	f	4.46	cdefg
WSU 2130	5.52	cd	4.38	defg
WSU 2482	3.78	f	4.32	efg
WSU 2088	6.03	cd	4.15	fg
WSU 2481	3.80	f	3.84	g
WSU 2001	5.81	cd	3.82	g
WSU 2188	3.85	f	3.24	g
[z]Yield is based on 8-plant plots and estimated in tons assuming 1960 plants per/acre.				
[y]Means followed by the same letter within a column are not significantly different using Fisher's Least Significant Difference Test at $p < 0.05$.				

Grower Trials.
Seven advanced selections are currently in grower trials or are being advanced to grower trials.

WSU 2130. This is probably being discontinued because yields are not high and because it is susceptible to RBDV, perhaps causing yield issues. 6 grower sites, very high yielding in Puyallup, North Willamette, and Enfield's over two harvest seasons. 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 and good firmness. Tolerant to root rot, appears to have better field tolerance than 2069. Very good winter hardiness. Early fruiting, full canopy, good flavor. This is going into virus clean up for potential commercialization.

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. This is going into virus clean-up for potential commercialization.

WSU 2088. This is probably being discontinued because yields are not high and because it is susceptible to RBDV, perhaps causing yield issues. 4 grower sites, high yields at PREC; high yield, and excellent firmness in nonreplicated grower trial compared with 'Wakefield'. Overall dark color berries of medium size. Late season selection.

WSU 2087. This is our top advanced selection for overall excellent and sustained high yields and fruit quality. It is susceptible to RBDV and is being monitored for longevity. Patent data has been collected. 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 was excellent in intense disease year of 2022.

Root rot evaluations. Farm 5 at PREC has documented 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 PREC as indicated by the table below. Each planting contains single-plant plots in four replicates. Third-year results for the 2022 planting are included in Table 5. Table 6 outlines accomplishments for root rot evaluations.

Table 5. Root rot response in 2024 of WSU and BC selections and standard cultivars planted in 2024 in a root rot infested area at PREC.

Clone	Ratings[z]	
	2023	**2024**
WSU 2557	4.3	5.0
WSU 2298	3.8	4.5
WSU 2376	4.3	4.5
WSU 2472	4.0	4.0
WSU 2653	4.8	4.0
WSU 2029	5.0	3.5
WSU 2268	3.8	3.3
Cascade Bounty	2.5	3.0
WSU 2234	3.5	3.0
WSU 2372	4.5	3.0
WSU 2377	2.8	2.8
WSU 2425	2.8	2.5
WSU 2561	2.3	2.5
WSU 2641	3.3	2.3
WSU 2563	2.5	2.0
WSU 2575	3.3	1.8
WSU 2616	4.5	1.8
WSU 2564	3.3	1.3
WSU 2654	3.8	1.3
BC 1748.12	0.5	1.0
WSU 2082	3.5	1.0
WSU 2571	3.0	0.8
BC 1855.37	1.8	0.5
Meeker	2.0	0.5
WSU 2088	4.8	0.0

[z]Rating was on a scale 0-5, where 0 =dead plant; 5= vigorous with no root rot symptoms.

Table 6. Accomplishments, tasks, and highlights for root rot evaluation trials.

Establish-ment year	Number of selections	Tasks and highlights
2021	21 WSU, 3 cvs	Maintained; evaluated selections for 4th time for disease symptoms and overall vigor.
2022	21 WSU, 23 ORUS, 3 BC, 2 cvs	Maintained; evaluated selections for 3rd time for disease symptoms and overall vigor.
2023	7 WSU, 14 ORUS	Maintained; evaluated selections for 2nd time for disease symptoms and overall vigor.
2024	8 WSU, 15 ORUS, 3 cvs,	Established; evaluated selections for 1st time for establishment.

Collaborative genetic research. A third year of data and collaboration was accomplished on a project to study genomic selection for tolerance to root lesion nematode (RLN) in red raspberry. This project leverages investment by the WRRC in raspberry plant breeding to contribute genetic resources and methods to evaluate a unique replicated panel of 270 raspberry clones representing the combined diversity of germplasm from WSU, British Columbia Berry Cultivar Development Inc., United States Department of Agriculture/Oregon State University, and the National Clonal Germplasm Repository. Genotyping-by-sequencing information was generated to conduct a genome-wide association study for RLN resistance in 2024. This is impactful work that has the potential to generate parents and useful markers for nematode resistance for cultivar development.

2025 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

Continuing Project Proposal **Proposed Duration: 1 year**

Project Title: Red Raspberry Breeding, Genetics and Clone Evaluation

PI:	Wendy Hoashi-Erhardt	**Co-PI:**	Lisa Wasko DeVetter
Organization:	WSU Puyallup	**Organization:**	WSU Mount Vernon
Title:	Program Lead	**Title:**	Associate Professor
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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, Amanda Lake, and Dimitre Mollov, Ioannis Tzanetakis, 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, grower-cooperator; regional growers.

Year initiated: 1987 **Current year:** 2025 **Terminating Year:** continuing

Project Request: $ 80,801

Other funding sources:
Agency Name: Northwest Center for Small Fruits Research
Amt. Awarded: $65,000
Notes: Funds will be used to provide partial technical support for the program.

Agency Name: WSDA Specialty Crop Block Grant
Amt. Awarded: $178,245 for years 2024-2027
Notes: Funds are to explore the genetic basis for fruit and yield traits, leading to the development of molecular tools for marker assisted selection in plant breeding.

Description: The program will develop new red raspberry cultivars for use by commercial growers in the Pacific Northwest, with selection priority on high yield, machine harvestability, superior processed fruit quality, root rot tolerance, nematode tolerance, and raspberry bushy dwarf virus (RBDV) resistance. 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. Traditional breeding methods will be used, as well as molecular tools that become available and are efficient and affordable. 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. 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, which is one of three US public programs breeding floricane-fruiting red raspberry and the only one with major focus on machine-harvested yield potential and excellent fruit quality for the processing market.

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 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 leverages investment from the WRRC to obtain new funding for research valuable to WRRC growers, such as evaluating available germplasm to develop molecular breeding tools, such as with our project on genomic selection for root lesion nematode resistance, an economically important pest to raspberry production.

WSU's plant breeding program is a vital collaborator with BC, Oregon, Washington private and public plant breeders, plant pathologists, and horticulturists who work cooperatively to test important germplasm, conduct regional evaluations, and explore emerging research needs.

Relationship to WRRC Research Priorities: This project addresses a first-tier priority of the WRRC to 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.

Procedures

1. Parental/germplasm material. PREC, NWREC, establish new accessions and maintain existing plantings.
2. Crosses. PREC. Select parents based on 2024 data and research priority. Perform crosses spring 2024; Seed germination and seedling propagation, Sept 2025 to spring 2026.
3. Seedlings. Lynden cooperator. Identify excellent individuals (selections) to enter cultivar development pipeline from 2023 crosses; establish 2025 seedling field and maintain 2024 seedling field at Rader Farms.
4. Observational machine harvest (MH) trial. Lynden cooperators. New selections are propagated and tested for machine harvestability, yield, and fruit quality. Status: 2022

trial at Honcoop's and 2023 trial at Rader's will be evaluated in 2024; 2024 MH trial maintained for evaluation next year; 2025 MH trials will be established with Brad Rader.

5. Replicated yield trial. Lynden cooperators. High performing selections from MH trial are evaluated in replicated plots for yield and fruit quality. Status: 2022 and 2023 rep trial will be evaluated for yield and fruit quality; 2024 rep trial will be maintained for evaluation next year; 2025 planting to be planted with Rader Farms.
6. Root rot trial. PREC. Root rot response is evaluated in comparison with standard cultivars for 3 years. Status: Root rot plots planted in 2022, 2023, and 2024 will be maintained and evaluated for tolerance in 2025. A new planting will go in in 2025.
7. Regional replicated trials. Dossett/BC, Hardigan/OR. Selections from replicated yield trials are evaluated in replicated plots for yield and fruit quality across growing environments.
8. Grower Trials. Walters, Pond/NBF. Two to six elite selections will be propagated, cleaned, 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.
9. Propagation. PREC. Generate multiple plants of single, genetically unique selections through tissue culture and greenhouse methods for all the plantings listed above.
10. Plant IP preservation. PREC. Maintain and preserve core and experimental germplasm, transfer plant material and document IP status for cultivars and advanced selections.
11. Virus testing. PREC, 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.

Anticipated Benefits and Information Transfer: The program will continue annual plant breeding activities that lead to genetic gain for economically important traits and to the release of elite red raspberry cultivars. Additionally, the program will preserve germplasm, develop cooperative evaluation and phenotyping protocols, further transition plant breeding activities to Whatcom County, and leverage WSU germplasm for 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.

Budget:

Budget		2025-2026
Salaries - 00		$ 24,189
Plant Technician (0.30 FTE)	$ 16,567	
Ag. Res. Tech. 2 (2 months)	$ 7,622	
Time-slip Wages - 01		$ 21,170
Goods/Services - 03		$ 18,000
Machine harvest trials, including rep. yld trial	$ 12,000	
Supplies	$ 6,000	
Travel - 04		$ 2,400
Benefits - 07		$ 15,042
Total Direct Costs		**$ 80,801**

Budget Justification

Salaries and Wages:
Plant Technician 3. Plant Technician Brad Pugh will work soils, maintain equipment, design and plant plots, scout and treat pest problems, prune, trellis, run irrigation and fertilizer regimes, keep inventories and documentation, and supervise temporary employees, 0.30 FTE ($16,567).
Agricultural Research Technologist 2 (ART2)– NWREC. ART2 Emma Rogers will collect data and process fruit samples for 2 months full time in summer 2025 ($7,622).
Non-permanent scheduled ART3 - PREC. An ART2 will conduct tissue culture and greenhouse propagation, at a wage of $24.10/hr for 10 hrs/week for 50 weeks ($12,050)
Non-permanent class staff. Seasonal workers will harvest fruit, collect data under supervision of PIs, maintain plots, and coordinate other data activities at grower field in MH trial. This equates to 480 hours at $19/hr ($9,120).

Benefits. Plant Technician 3 benefits are $8,885 for 0.30 FTE. ART2 benefits for Emma Rogers amount to $3,998. Non-permanent classified staff benefits amount to $2,159.

Goods and Services.
Machine harvesting (MH) trials**.** Cooperating grower is paid as a service contractor to maintain MH trial, harvest plots, collect data, and communicate with researcher. Total is $12,000.
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 is required to visit to trial plots, meeting with collaborators, and present results are estimated to be 6 trips between Puyallup and Lynden (round trip and local = 300 miles x $.67/mile x 6 trips - $1,206 in one year, and 5 nights in a hotel in Lynden (5 x $120 = $600), plus local mileage for PIs and employees amounting to 886 miles ($621).

Title: On-farm trials of Advanced Raspberry Selections

Personnel: Thomas Walters, Walters Ag Research (PI). Co-PI's: Julie Pond, Michael Hardigan, Wendy Hoashi-Erhardt, Julie Enfield. Cooperators: Eric Gerbrandt, Rob Dhaliwal, John Clark

Reporting Period: 2024

Accomplishments: Evaluated five advanced selections from the WSU raspberry breeding program in trials at four locations, in comparison with Wakehaven, Kulshan and Cascade Pemier

Results: We scouted and evaluated plants and fruit at four locations:

- A 2020-planted small plot trial on Bob Hall Road. Field variety Wakehaven, plots of WSU 2188, WSU 2088, WSU 2087 and WSU 2130.
- A 2020-planted small plot trial on Havemann Road. Field variety Cascade Premier, plots of ORUS 4607-2 (discarded), WSU 2130, WSU 2088.
- Block trial on Van Dyk road of Kulshan, WSU 2088, WSU 2069
- Block trial on Noon road of WSU 2188; single row WSU 2087 present

WSU 2188

- Long fruiting laterals break, especially in the first harvest year. Manage vigor.
- Primocanes were damaged by harvester at one location. They are very long at harvest, and can bend/break over training wires.
- Outstanding fruit quality, excellent for IQF processing.
- Fruit is long and conic. Firm, but soft following a rain.
- Winter Hardiness intermediate between WakeHaven® and Cascade Premier
- Moderately susceptible to cane botrytis, but not extremely so.
- Susceptible to Spur Blight
- A few RBDV positive plants in year 3
- Yield potential good, manage breakage in first harvest year
- First harvest a bit earlier than you think-fruit releases easily, even before deeply colored. Harvest starts and ends later than Wakehaven
- Root rot damage less than Wakehaven in small plot trial on Bob Hall. Overall root rot resistance looks good.
- Some susceptibility to sunburn, at least compared with WSU 2087 and WSU 2088.

WSU 2069

- High-yielding, firm, early fruiting selection.
- Slender primocanes are abundant. May require different timing for caneburning.
- Harvest begins well ahead of WSU 2088 and Kulshan. Harvest ends with Kulshan.
- Fruit size initially large, but drops off significantly in second half of harvest.
- Winter hardy
- Good root rot resistance

- Druplets on some plants are irregular and rough-looking
- Cane Botrytis similar to Cascade Premier.
- Low incidence of Cane Blight in a planting where other selections were notably affected.
- Do not advance yet; possible re-evaluate once drupelet issue resolved

WSU 2088

- Excellent yield potential, 24+ fruits/lateral
- Fruit rounded, firm, large, heavy. Uniform, attractive on harvester
- 30+ fruits/lateral, but laterals more compact than WSU 2188 and less likely to be damaged.
- Harvest begins later than Wakehaven, similar to WSU 2188. Continues well past Wakehaven, up to 2 weeks after WSU 2188.
- Slightly less winter hardy than 2087
- Less cane Botrytis than Cascade Premier or Wakehaven
- Much less cane blight than Kulshan
- Thick canopy, notable fruit Botrytis
- Purplish color to fruit
- Root rot response mixed. Looked very good on Bob Hall Road, but was severely damaged in a low spot on Van Dyk road.
- Failed to perform well on Havemann road-cause unknown, possibly root rot.

WSU 2087

- Very good early yield potential
- Vigorous plants, thick primocanes. More compact than 2188. Laterals shorter than 2188, but more fruits per lateral.
- Fruit large, rounded, consistent size. Possibly softer than Wakehaven. Fruit can sunburn, similar to Wakehaven. Fruit purplish when overripe
- Fruit rot following rain.
- About 15 fruits per lateral. Harvest starts slightly after Wakehaven
- Less Cane Botrytis than Cascade Premier or WSU 2188, but still susceptible. Lesions often associated with wounds.
- Harvester damage minimal, notably less than WSU 2188.
- Root rot resistance good so far, but only planted in two locations

WSU 2130

- Compact plants, fruit presented outside canopy
- Good yield potential, 15-25 fruits/lateral
- Fruit relatively small, conic, uniform, releases easily.
- Winter hardy
- Harvest begins and ends just after Wakehaven.
- Laterals extend past canopy, presenting fruit outside.
- Did not perform well under heavy root rot pressure. Root rot resistance probably less than other WSU selections here
- Sunburns somewhat, but less so than Wakehaven.
- Less cane Botrytis than Cascade Premier, but more than most other WSU selections. Will require cane Botrytis management.
- Spur blight noted on this selection.

Publications:

- Comments shared at Mechanical Harvesting Field Day, July 2024
- Note in Small Fruit Update (planned, winter 2024-2025)

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
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15696 Yokeko Drive
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
Michael Dossett, BC Berry Council, Abbotsford, BC

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

Year Initiated 2024 Current Year 2025 Terminating Year 2026

Total Project Request: 2025: $5,296

Other funding sources:

In-kind contributions: $450 (estimated 300 plants for trials in 2024. 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.

We will evaluate plants and fruit at four locations:

- A 2020-planted small plot trial on Bob Hall Road. Field variety Wakehaven, plots of WSU 2188, WSU 2088, WSU 2087 and WSU 2130.
- A 2020-planted small plot trial on Havemann Road. Field variety Cascade Premier, plots of ORUS 4607-2 (discarded), WSU 2130, WSU 2088.

- Block trial on Van Dyk road of Kulshan, WSU 2088, WSU 2069
- Block trial on Noon road of WSU 2188; single row WSU 2087 present

In addition, we will coordinate planting of one or two grower trials of the new WSU selections WSU 2348 and WSU 2376. Plants of these were recently received by Northwest Plants, and may be available for fall planting. 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. Pending plant availability, new trials will be established in 2024, with potential selection from WSU, USDA and BC breeding programs.

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 caneberry 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 2025, we will:

- Make continuing evaluations on the three spring-planted 2020 trials, and on the fall-planted 2020 trial, as well as larger trials of WSU 2188, WSU 2088, WSU 2069 and WSU 2087. Evaluations will include periodic pest monitoring as well as evaluation of fruit quality and harvest.
- 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 evaluate selections in the 2020 trials, including WSU selections 2068, 2069, 2087, 2088, 2130 and USDA selection ORUS 4607-2. These small plot evaluations will focus on winter injury, vigor, fruit quality, and response to other diseases and pests. Evaluations will take place April through August.

Specific diseases and pests that will be scouted for include:

- Cane botrytis. Evaluate floricanes with floral buds killed by cane Botrytis early in the season. Evaluate cane botrytis lesions on primocanes later in the season, beginning approximately mid-harves
- Cane Blight. Look for killed floricanes early in season through harvest, look for cane blight lesions in late fall.
- Spur blight. Look for lesions late harvest-September
- Leaf rust. Look for lesions through summer months
- Aphids. Look throughout season, especially before mid-July
- Mites. Look from pre-harvest through the end of harvest.

Pending plant availability, a new trial with WSU, USDA and BC selections will be planted with a grower-cooperator in 2025.

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

	2025
Salaries[1/]	**$3,000**
Travel[2/]	**$571**
Outreach[3/] `	**$1,500**
Other (Propagator payments**)**[4/]	**$ 000**
Offices costs (to NBF**)**	**$ 225**
Total	**$5,296**

Budget Justification

[1/] **Salaries**
Tom Walters—3%FTE, including benefits = $3,000

[2/] **Travel & related expenses**
Tom Walters—6 trips a year at 140 miles per day at $ .68 per mile = $571

[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 paid in 2023, but not yet used. To be used in 2025.
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 2024 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: 2024

Accomplishments:
- Established ~2,100 seedlings in the field
- Established a new machine-harvest yield trial (112 genotypes, replicated)
- Harvested and evaluated seedlings (~11,000 genotypes)
- Made 81 new selections for further evaluation
- Harvested and evaluated yield-trials (2020, 2021, and 2022 plantings)

Results:
Overall, yields in all of our trial plots were down a bit from past years, with fruit size and firmness in the early season suffering a bit from heat. Decline in yield was particularly noticeable in the 2020 planting, which overall seemed to have higher incidence of spur blight and had reduced budbreak, in addition to heavy RBDV pressure indicating many susceptible genotypes. Standout selections are noted below.

2020 planting
BC 10-79-33: Continued to be the highest yielding selection in the trial plot (6.5 t/a in 2024). A few days later than Meeker. Looks good in tray but has tendency toward softness. Expect this to probably be dropped as quality in 1855 selections is significantly better.
BC 1653.7: Yield similar to Chemainus (5.0 t/a in 2024). Lots of fruit early in season. Fruit in flats looked quite good, but were noticeably soft, much more so than in previous seasons.
BC 10-71-27: Earlier and firmer than BC 1653.7 (4.8 t/a in 2024).

2021 planting
BC 1855.14: Highest yielding in this planting (5.8 t/a in 2024). Very firm and good grower. A few days after Meeker
BC 1855.11: Exceptional fruit quality. Concentrated yield but is in mid-late season (5.1 t/a).

2022 planting
BC 1855.14: 2nd highest yielding in this trial (6.4 t/a); impressive fruit quality and plant health.
BC 1747.32: Good quality, strong yields and early (6 t/a, >90% of harvest by July 15).
BC 1750.56: Good quality, strong yields and early (5.9 t/a, >90% of harvest by July 15).

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
	Current:				
Michael Dossett	**Pending*:** AAFC, BCBC, LMHIA	$1,496,551	Sept 6, 2023 – March 31, 2028	60%	Blueberry Germplasm and Cultivar Development for the Pacific Northwest
	AAFC, WRRC, RIDC, LMHIA	$872,988	Sept 6, 2023 – March 31, 2028	35%	Red Raspberry Germplasm and Cultivar Development for the Pacific Northwest
	AAFC, BCSGA, LMHIA	$124,713	Sept 6, 2023 – March 31, 2028	5%	Strawberry Germplasm and Cultivar Development for the Pacific Northwest

Our project has been submitted to Agriculture and Agri-Food Canada for potential funding through March 2028. We are expecting finalization early in the new year regarding funding, with an anticipated 50/50 ratio of government and industry funds.

2025 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

Continuing 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** __2025__ **Terminating Year** __2025__

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

Other funding sources:
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: $2,494,251 ($872,988 for raspberries, see note below)
Notes: In 2023, we submitted our project to Agriculture and Agri-Food Canada's "Sustainable Canadian Agricultural Partnership" program for funding through March 2028 as part of a package with other research projects the industry is trying to support in the berry space. In late spring of 2024, we received word from AAFC regarding which project activities they were willing to fund and at what levels, with AAFC requesting revisions to the submission that reflected this. Revisions were submitted in August and agreements are still being finalized with AAFC. The total project amount here is less than our previous submission to WRRC and represents the revised amounts submitted to AAFC in August 2024 for September 2023-March 2028. Our project is split between blueberries, raspberries, and strawberries, with raspberries accounting for ~$35% of time/effort. The total budget from April 1 2023-March 31, 2028 is $2,494,251, with $1,068,672 of this for the raspberry work. We are expecting a 1:1 matching ratio of government:industry funding. The funding we are asking from WRRC will help to offset the required industry contribution and will be used specifically to help hire summer labor for planting, harvest, and field care.

Description: (less than 200 words) describing objectives and specific outcomes
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 make new crosses, select seedlings from past years' crosses, 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 second 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.

References:

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

	2023	**2024**	**2025**
Salaries[1/]	$	$	$
Time-Slip	$10,00	$10,00	$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 season spent on vegetative data collection, planting, and field management. See note above regarding matching ratios and how these fit into the overall picture.

[1/]Specify type of position and FTE.

[2/]Provide brief justification for travel requested. All travel must directly benefit project. Travel for professional development should come from other sources. If you request travel to meetings, state how it benefits project.

[3/]Justify equipment funding requests. Indicate what you plan to buy, how the equipment will be used, and how the purchase will benefit the growers. Include attempt to work cooperatively with others on equipment use and purchase.

[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 2024 Projects

Project No:

Title: Cooperative raspberry testing and cultivar development program

Personnel: Michael Hardigan, USDA-ARS-HCPGIRU
Wendy Hoashi-Erhardt, Program Lead, WSU Puyallup REC
Scott Lukas, Berry Crops Research Leader, OSU-NWREC

Reporting Period: 2024

Accomplishments:

- Contributed to release of new raspberry cultivar WSU 2188, A.K.A., 'Cascade Legacy™' with pending patent.
- Identified WSU 2130 (Table Ry-FL 2) as an elite performer. Selection WSU 2130 showed excellent plant health, was higher yielding than other replicated selection, and produced berries of high quality that withstood machine harvest. The excellent fruit quality of WSU 2130 was notable due to exposure to several days of excessive heat during its harvest season. Susceptible to RBDV.
- Identified ORUS 4715-2, available at North American Plants, as a selection with potential for production in central Washington. Showed excellent heat tolerance during 2021 "heat dome" and withstand excessive heat and machine harvest in early July 2024. We tested ORUS 4715-2 in a trial as part of a heat tolerance study with by Lisa DeVetter, where it showed superior post-harvest quality compared to 'Meeker', 'Wakefield', and WSU selections and was able to achieve good quality under high temperatures.
- Observed WSU 2087 to possess elite IQF quality in terms of fruit durability and leakage, with essentially no leakage or crumbling in IQF samples

Results:

We 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). Results from replicated field trials showed that several WSU red raspberry selections, including WSU 2130, WSU 2088, and WSU 2188, were among the top performing red raspberry individuals in Oregon. Additional USDA selections ORUS 4715-2 showed excellent performance with regard to heat tolerance in central Washington, and ORUS 5439-2 showed excellent performance and fruit quality in the north Willamette Valley. These will be made available for grower trial at PNW nurseries. We identified newer primocane-fruiting types with fresh market and season-extension potential including recent cultivar release 'Finnberry' and new selection ORUS 5209-1 that improves on 'Finnberry' yields.

Publications:

- 'WSU 2188' Red Raspberry (*in review*)

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	09/2023-09/2024	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 2021 trial planting, harvested from 2023-24. Yield measurements are based on twice-weekly machine harvest using an Oxbo 7450 Harvester.

	Berry Size (g)	Yield (tons·a-1)		
Annual Mean				
2023	3.51			5.47
2024	3.21			3.06
Genotype	2023-24	2023	2024	2023-24
Replicated				
ORUS 4843-2	3.55	4.86	3.18	4.02
Meeker	**2.20**	**4.89**	**2.11**	**3.50**
Nonreplicated				
ORUS 5310-1	3.90	7.23	3.85	5.54
ORUS 5309-1	3.20	6.34	3.91	5.12
ORUS 5309-2	3.10	6.06	3.31	4.69
ORUS 5323-2	3.50	5.47	2.97	4.22
ORUS 5320-3	3.55	5.23	3.15	4.19
ORUS 5315-3	3.20	4.76	3.55	4.16
ORUS 5329-1	4.00	5.61	2.36	3.98
ORUS 5309-3	2.55	4.97	2.98	3.98
ORUS 5315-1	3.95	5.34	2.59	3.96
ORUS 4692-1	3.60	4.92	2.81	3.86

*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 2022 trial planting, harvested from 2024. Yield measurements are based on twice-weekly machine harvest using an Oxbo 7450 Harvester.

	Berry Size (g)	Yield (tons·a-1)
Annual Mean		
2024	3.33	3.77
Genotype	2024	2024
Replicated		
WSU 2130	3.10	5.67
Meeker	**2.20**	**3.80**
ORUS 5198-2	2.40	3.10
WSU 2082	2.23	0.94
Nonreplicated		
WSU 2564	3.20	6.42
WSU 2622	4.90	6.34
ORUS 5439-2	3.80	6.24
ORUS 5444-3	3.80	5.18
WSU 2737	3.70	4.88
ORUS 5443-2	4.00	4.77
**ORUS 4715-2*	2.90	4.62
ORUS 5442-5	4.60	4.35
ORUS 4371-4	3.50	4.19
WSU 2561	2.50	4.15
ORUS 4607-2	3.50	3.95
ORUS 5442-4	3.20	3.83
Lewis	**3.20**	**3.80**
ORUS 5434-1	3.70	3.79
Wakefield	**2.30**	**3.76**
Cascade Gem	**3.80**	**3.75**
WSU 2571	2.60	3.61
WSU 2641	2.40	3.35
ORUS 5432-3	4.60	3.09
ORUS 5441-3	3.80	3.09
Cascade Premier	**3.90**	**2.90**
WSU 2617	4.60	2.79
WSU 2613	2.60	2.76
ORUS 4600-1	2.70	2.51

ORUS 4692-1	3.80	2.42
ORUS 5441-2	3.40	2.31
ORUS 4462-2	2.60	2.28
Tulameen	**3.00**	**1.98**

*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 2022 trial planting, harvested from 2024. **2023 harvest skipped due to low plant health.*

	Berry Size (g)	Yield (tons·a-1)
Annual Mean		
2024	2.69	2.04
Genotype	2024	2024
Replicated		
Heritage	**2.17**	**3.24**
ORUS 5332-1	2.37	0.89
Nonreplicated		
Finnberry	**3.30**	**3.55**
**ORUS 5209-1*	3.50	3.18
ORUS 4494-3	3.10	2.75
ORUS 5450-1	2.40	2.60
ORUS 5446-3	3.80	2.58
ORUS 4858-2	2.70	1.93
ORUS 5446-2	2.40	1.88
**ORUS 4291-1*	2.30	1.52
ORUS 5445-3	3.10	1.41
WSU 2029	3.90	1.32
Vintage	**2.00**	**1.30**
ORUS 4725-1	2.10	1.24
ORUS 4487-1	1.20	1.18

*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 2023 trial planting, harvested from 2024.

	Berry Size (g)	Yield (tons·a-1)
Annual Mean		
2024	1.92	1.64
Genotype	2024	2024
Replicated		
[*] *ORUS 5209-1*	1.90	4.15
Finnberry	**2.13**	**2.69**
ORUS 5250-1	3.00	1.20
Nonreplicated		
ORUS 5549-1	2.20	2.00
Polka	**1.60**	**1.93**
ORUS 5549-3	1.90	1.72
ORUS 5452-2	2.40	1.69
ORUS 5447-2	1.60	1.56
Kokanee	**1.30**	**1.49**
Heritage	**1.00**	**1.49**
ORUS 5450-2	2.60	1.45
ORUS 5446-1	1.40	1.40
ORUS 5451-2	2.50	1.34
ORUS 5457-2	2.00	1.27
ORUS 5445-2	1.70	1.25
ORUS 5446-5	1.30	1.21
ORUS 5549-2	1.70	1.13
[*] *ORUS 4291-1*	1.90	1.12
ORUS 5452-4	2.30	1.08

[*] Nursery list – available at nurseries for grower trial by request.

2025 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

Project Title: Cooperative raspberry testing and cultivar development program.

PI: Michael Hardigan
Organization: USDA-ARS-HCPGIRU
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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
Michael Dossett, Berry Cultivar Development Inc.

Year Initiated __2013___ Current Year 2025-26 Terminating Year _Continuing__

Total Project Request: $7,000 (Ongoing project; annual request).

Other Funding Sources:

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 (Aurora, OR). The funding we are requesting is complementary.

Description: (<200 words)

- Develop 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
- Identify fresh market cultivars that provide "season extension: improve viability of fresh marketing" through floricane or primocane fruiting types
- Evaluate frozen quality and internal chemistry of machine harvested fruit samples and provide data/observations to WRRC on request

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 alongside WSU breeding program selections and cultivars in machine harvest trials held at the OSU-NWREC (Aurora, OR). We objectively measure yield and fruit size, subjectively evaluate machine-harvested fruit quality, and, beginning in 2025 will assess frozen quality at NWREC.

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 history of industry support for research and public breeding. The USDA-ARS caneberry breeding program in Oregon is working to develop cultivars that are commercially viable for the PNW region. We provide an additional environment for evaluating USDA and WSU raspberry experimental selections, including machine harvested fruit quality and yield, alongside cultivar standards. The Willamette Valley offers a location to evaluate plant health and fruit quality under different soil conditions and higher average temperatures than Lynden, WA. The Oregon (USDA) and Washington (WSU) breeding programs 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 supporting a genetic baseline of high machine-harvestable yields and fruit quality. Funding is essential to support maintenance and propagation of selections in the program, field costs, and annual machine harvest trials at the OSU-NWREC that generate valuable data informing the suitability of selections for variety release.

The OSU-NWREC trials also undergo virus testing on a rotating basis with field plots at Lewis Brown Farm (Corvallis, OR). These virus testing results assist in the identification of selections that are either resistant or slow to become infected with common PNW plant viruses including RBDV and SNSV.

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 IQF quality. Therefore, our activities indirectly contribute to the following research priorities:

- Foliar & Cane diseases – i.e. spur blight, yellow rust, cane blight, powdery mildew (1)
- Fruit rot including pre harvest, post-harvest, and/or shelf life (2)
- 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 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 Oxbo 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 IQF quality and internal chemistry in the off-season.

Selections that perform well over 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 machine harvest trials with WSU and private 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, fruit characteristics, or disease resistance 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 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: $ 7,000

	2023	2024	2025
Salaries[1/]	$6,000	$7,000	$7,000
Time-Slip	$	$	$
Operations (goods & services)	$	$	$
Travel[2/]	$	$	$
Meetings	$	$	$
Other	$	$	$
Equipment[3/]	$	$	$
Benefits[4/]	$	$	$
Total	**$6,000**	**$7,000**	**$7,000**

Budget Justification

Funds will be used to fund a summer research assistant to support the raspberry machine harvest trials at OSU-NWREC.

[1/]Student research assistant (GS-2, 1.0 FTE = $10,800).
[2/]No travel support requested.
[3/]No equipment support requested.
[4/]No benefits support requested.

Washington Red Raspberry Commission
Progress Report Format for 2024 Projects

Project No:

Title: Virus testing of PNW public raspberry breeding programs.

Personnel: Michael Hardigan, USDA-ARS-HCPGIRU
Wendy Hoashi-Erhardt, Program Lead, WSU Puyallup REC

Reporting Period: 2024

Accomplishments:

- Verified virus infection status of three common viruses, RBDV, SNSV, and ToRSV, in breeding program field plots and propagation facilities
- Identified several selections that may be either virus resistant or have delayed onset of virus infection, used to develop new families for evaluation in subsequent years.

Results:

RBDV and SNSV were commonly observed in both red and black raspberries in 2023. In 2024 at Lewis Brown Farm, raspberries showed more common infection from SNSV than RBDV, with red raspberries mostly free of RBDV in the field. Nearly all red raspberries over 5 years old at Lewis Brown Farm were infected with SNSV, indicating broad susceptibility. We observed approximately 40% SNSV infection of black raspberry and 5-10% SNSV infection of red raspberry in the HCRL unit location's canyard in 2024, indicating there continues to be a significant risk of propagating virus-infected material from fields. ELISA screening continues to assist in prevention of the spread of virus through crossing or distribution of infected plant material. ToRSV appears to pose the lowest risk of infection at the moment. Raspberry selections that have remained virus-free for 6 or more years will be used as parents to develop new selections that are slow to develop infection. **ORUS 5083-1 is a hybrid derived from the Korean black raspberry and appears to be a potential source of resistance or delayed infection from both RBDV and SNSV, able to persist without infection in a seven-year-old field.** This selection was successfully used to develop new crosses for both red and black raspberry. **RBDV: 2023 (OSU-NWREC) -** Approximately 25% of red raspberries were infected. Notable selections that remained free of infection (5+ years): Cascade Harvest, Finnberry, Heritage, Kokanee, Meeker, ORUS 4487-1, ORUS 4858-2, ORUS 4978-3, ORUS 5114-1, Vintage, and Wakefield. **2024 (OSU-LBF)** - Approximately 5-10% of red raspberries were infected at OSU-LBF. No new selections with low susceptibility detected. **SNSV: 2023 (OSU-NWREC) -** Approximately 35% of red raspberries were infected. Notable selections that remained free of infection (5+ years): ORUS 4858-2, ORUS 4961-1, ORUS 4965-3, ORUS 4974-1, ORUS 4978-3, ORUS 5106-1, ORUS 5114-1, ORUS 5250-1, Polka, Wakefield, and Wakehaven. **2024 (OSU-LBF) -** Approximately 50% of red raspberries were infected. All selections in 5+ year old plots) were infected with the exception of ORUS 5114-1, a primocane fruiting selection with some promise for late summer production.

Publications:

None.

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	09/2023-09/2024	10%	Cooperative Caneberry Breeding Program - Cultivar and Selection Evaluation, NWREC
Pending:					

Appendix II: Tables

Table 1. Confirmed susceptibility (S) for relevant cultivars and nursery list selections tested at OSU-NWREC in 2023 and OSU-LBF in 2024 for RBDV, SNSV, and ToRSV. Clean status does not indicate resistance, only that the tested plants did not contain virus.

Red Raspberry	**Oldest Plot**	**RBDV**	**SNSV**	**ToRSV**
Cascade Harvest	2018	-	-	-
Crimson Treasure	2021	-	S	-
Finnberry	2020	-	S	-
Heritage	2018	-	-	-
Kokanee	2018	-	S	-
Meeker	2018	-	S	-
ORUS 4487-1	2018	S	S	-
ORUS 4600-1	2020	S	S	-
ORUS 4715-2	2019	S	S	S
ORUS 4725-1	2019	-	S	-
ORUS 4858-2	2019	-	-	-
ORUS 4974-1	2018	S	-	-
ORUS 5106-1	2019	S	S	-
ORUS 5209-1	2019	-	S	-
ORUS 5250-1	2019	-	S	-
Polka	2018	-	S	-
Vintage	2018	-	S	-
Wakefield	2018	-	-	-
Wakehaven	2018	-	-	-
WSU 2069	2020	S	-	-
WSU 2087	2020	S	S	-
WSU 2088	2019	S	S	-
WSU 2130	2022	-	-	-
WSU 2277	2019	S	-	-
WSU 2376	2018	-	-	-
WSU 2425	2020	-	S	-
WSU 2472	2020	-	S	-
WSU 2481	2019	S	S	-
WSU 2605	2019	-	S	-

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

PI: Michael Hardigan
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Collaborators: Wendy Hoashi-Erhardt, Program Lead, WSU Puyallup REC
Mary Peterson, Technician, USDA-ARS, HCPGIRU

Year Initiated __2023___ **Current Year** 2025-26 **Terminating Year** _2025_

Total Project Request: $18,000 ($6000/yr from 2023-2025)

Other Funding Sources:

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 selections.
- 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 pollen-vectored 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 Willamette 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 occurred and which viruses were present.

<u>Anticipated Benefits and Information Transfer: (<100 words)</u>

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 varieties, or that will complement the production season of current varieties. 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: $ 6,000

	2023	2024	2025
Salaries[1/]	$3,000	$3,000	$3,000
Time-Slip	$	$	$
Operations (goods & services)	$3,000	$3,000	$3,000
Travel[2/]	$	$	$
Meetings	$	$	$
Other	$	$	$
Equipment[3/]	$	$	$
Benefits[4/]	$	$	$
Total	**$6,000**	**$6,000**	**$6,000**

Budget Justification

[1]Laboratory research assistant responsible for sample preparation and analysis
[2/]No travel support requested.
[3/]No equipment support requested.
[4/]No benefits support requested.

ENTOMOLOGY

A Report to the Washington Red Raspberry Commission

Title: Two-Spotted Spider Mite and Thrips Control in Raspberry

Year Initiated: 2024 **Current Year**: 2024 **Terminating Year**: 2025

Principal Investigator:
Alan Schreiber, 2621 Ringold Road, Eltopia, WA 99301, aschreb@centurytel.net
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Justification and Background:

Two-Spotted Spider Mites (TSSM)

Historically, two-spotted spider mites (TSSM) 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) restrict 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. Second, 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 TSSM 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 were screened for bifenazate resistance as part of this project and all tested positive for presence of resistance to the miticide. This means that reliance on bifenazate should be immediately reduced. New miticides have been registered for raspberry but lack the necessary MRLs to allow for export.

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.

Thrips

Based on feedback from the industry, there is an interest in an efficacy trial targeting thrips. There is an expectation that there will be a related proposal from Washington State University focusing thrips biology and identification. Thrips have not historically been considered a pest of consequence in raspberry in Washington. However, we assume that the primary thrips involved is western flower thrips, *Frankliniella occidentalis* or at least in the genus *Frankliniella*. The damage in 2023 was widespread in northwest Washington and was of great concern to growers and processors of raspberry. Adult thrips are small (about 1-2 mm long at maturity), slender insects with fringed wings. They are generally white when young but brown or black when mature. Larvae are very tiny and difficult to distinguish without magnification. They feed by puncturing plant material, often blossoms, and sucking out the cell contents. Injured blossoms often turn into distorted fruit. When feeding on flowers, affected petals appear stippled or are scarred with brown streaks or spots. When unusually abundant in spring, thrips have been reported to cause blossom blasting. Fruit may be misshapen or distorted. Controls are most effective when applied at flowering; field control is not practical in eliminating thrips present at harvest. Applications at flowering has the additional challenge of applying insecticides that are safe to pollinators. *The picture to the left shows feeding damage of thrips on the fruit during 2023.* We propose to screen existing registered insecticides and additional unregistered products for efficacy against thrips. An additional complication is that in order to control thrips applications will be required during bloom time limiting early season to products that are low risk to pollinators. Many traditional thrips insecticides are not safe to use around bees.

Materials and Methods

Researchers in Agriculture Development Group, Inc. conducted three individual trials, including two insecticidal trials to investigate the efficacy of different insecticides for control of two-spotted spider mite (TSSM) (trial 1) and thrips (trial 2) in raspberry. Trial 1 (TSSM) also partially emphasized at the potential TSSM resistant issue for Acramite which has brought concerns from some growers. The 3rd trial is a survey trial where we collect information on TSSM biology – including a seasonal phenology on when mites first appear on raspberry to determine when first application should begin. All trials were conducted in a commercial raspberry field in northwest WA near Everson. The experimental design for both trials were RCB with 4 replications and plot sizes of 10ft x 25ft. Applications for this trial were made with an over-the-row sprayer calibrated to apply treatment sprays at 85 gallons per acre (Photo 1).

For the TSSM trial 1, three applications were made on 7/11 (A), 7/18 (B), and 7/25 (C). To assess the mite population, 20 leaves per plot were collected and at 0, 7, 14, 21, and 28 days after application A (DAA), and the mites were collected from the leaves using a mite-brush and counted under magnifier (Photo 2).

For the thrips trial 2, two applications were made 7/2 (A), 7/9 (B), and 7/16 (C). Beat sheet method was used to assess both sides of the raspberry row (2 sampling per plot) (Photo 3) at 0, 7, 14, and 21 days after application A (DAA) for number of thrips. Cumulative number of total thrips was calculated by summing the number from 7 to 21 DAA for each plot.

For the TSSM biology trial 3, we collected data on mites from six fields. Raspberry leaves were collected, packaged and shipped to ADG where they were counted using the same method as trial 1 for mite population.

Table 1. Treatment list for the TSSM trial.

Trt No.	Treatment Name	Rate	Rate Unit	Appl Code
1	Untreated Check			
2	Fujimite SC	2	pt/a	AB
3	Kanemite 15 SC	31	fl oz/a	AB
4	Aza-Direct	3	pt/a	AB
5	Savey 50 DF	6	oz/a	AB
6	Acramite 4sc	16	fl oz/a	AB
7	Brigade 2 EC	6.4	fl oz/a	AB
8	Danitol 2.4 EC	16	fl oz/a	AB
9	Oberon 2SC	16	fl oz/a	AB
10	Nealta	13.7	fl oz/a	AB
11	Zeal	3	oz/a	AB
12	Miteus	2	pt/a	AB
13	Magister	36	fl oz/a	AB
14	Bexar	27	fl oz/a	AB
15	Allicurb	48	fl oz/a	AB
16	Plinazolin	1.6	fl oz/a	AB
17	Entrapment FV	0.0625	% v/v	AB
18	CinnAcar	45	fl oz/a	ABC
19	Wrath	32	fl oz/a	ABC
	Kinetic	0.125	% v/v	ABC
20	Wrath	48	fl oz/a	ABC
	Kinetic	0.125	% v/v	ABC
21	Vendex	2	lb/a	A

Tabel 2. Treatment list for the thrips trial.

Trt No.	Treatment Name	Rate	Rate Unit	Appl Code
1	Untreated Check			
2	Aza-Direct	1.5	pt/a	ABC
	Pyganic	1	qt/a	ABC
3	Rango	1.25	% v/v	ABC
4	Assail 30SG	5.3	oz/a	ABC
5	Verdepryn	11	fl oz/a	ABC
6	Malathion 8F	2	pt/a	ABC
7	Delegate WG	6	oz/a	ABC
8	Success	6	fl oz/a	ABC
9	Exirel	20.5	fl oz/a	ABC
10	Sivanto	14	fl oz/a	AB
11	CinnAcar	32	fl oz/a	ABC
12	Plinazolin	3	fl oz/a	ABC
13	Beleaf	2.8	oz/a	ABC
14	Entrapment FV	0.125	% v/v	ABC
15	Wrath	32	fl oz/a	ABC
	Oroboost	0.125	% v/v	ABC
16	Wrath	48	fl oz/a	ABC
	Oroboost	0.125	% v/v	ABC

Results and Discussion

Two-Spotted Spider Mite Efficacy-Trial 1

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

While not statistically different from untreated check's 1.3 TSSM per 20 leaves at 7 DAA, Kanemite, Aza-Direct, Savey, Acramite, Danitol, Magister, Plinazolin, higher rate of Wrath at 48 fl oz/a, and Vendex had only 0 to 0.5 TSSM, indicating 62% to 100% control compared to untreated check's 1.5 TSSM (Table 3 column 2).

By 7 days after application B (7 DAB = 14 DAA), TSSM number increased to 1.5 per 20 leaves in untreated plots. Except Fujimite's 1.5 TSSM and Brigade's 1 TSSM counts, most treatments maintained 0 to 0.5 TSSM which were 67 to 100% significantly lower than untreated check (Table 3 column 3).

Mite pressure further developed and reached 2.3 and 3.5 counts per 20 leaves at 21 DAA (7 days after C, DAC) and 28 DAA (14 DAC). Although no more statistical separation among the treatments and untreated were observed, most treatments still numerically reduced the TSSM number by 28 DAA with a range of 0 to 2 TSSM, where Nealta, Bexar, and Wrath at low rate lost their effect with 3.5, 3, and 4 TSSM, respectively

(Table 3 columns 4 and 5).

Cumulatively, untreated plots resulted in a total of 8.5 TSSM counts per 20 leaves. Kanemite, Aza-Direct, Savey, Acramite, Danitol, Zeal, Miteus, Magister, Allicurb, Plinazolin, Entrapment FV, CinnAcar, Wrath high rate, and Vendex achieved the best control with only 0.8 to 2 total TSSM, followed by Brigade at 3.5, Oberon at 3, Bexar at 4.5, Wrath low rate at 6, Nealta at 6.5, and Fujimite at 6.5 total TSSM (Table 3 column 6).

Table 3. ANOVA table for the mean separation of TSSM counts for different treatments for trial 1.

Rating Date					7/11/2024	7/18/2024	7/25/2024	8/1/2024	8/8/2024	
Rating Type					count	count	count	count	count	Total no 0d
Rating Unit					#	#	#	#	#	#
Sample Size					20 leaves	20 leaves	20 leaves	20 leaves	20 leaves	20 leaves
Pest Name					TSSM	TSSM	TSSM	TSSM	TSSM	TSSM
Days After First/Last Applic.					0, 0	7, 7	14, 7	21, 7	28, 14	
Trt	Treatment		Rate	Appl	1	2	3	4	5	6
No.	Name	Rate	Unit	Code						
1	Untreated Check				0.3 a	1.3 a	1.5 a	2.3 a	3.5 a	8.5 a
2	Fujimite SC	2	pt/a	AB	0.3 a	4 a	1.5 a	0 a	1 a	6.5 a
10	Nealta	13.7	fl oz/a	AB	0 a	2.3 a	0 c	0.8 a	3.5 a	6.5 a
19	Wrath	32	fl oz/a	ABC	0.8 a	1 a	0.3 bc	0.8 a	4 a	6 a
	Kinetic	0.125	% v/v	ABC						
14	Bexar	27	fl oz/a	AB	1.3 a	0.8 a	0 c	0.8 a	3 a	4.5 a
7	Brigade 2 EC	6.4	fl oz/a	AB	0 a	0.8 a	1 ab	0.5 a	1.3 a	3.5 a
9	Oberon 2SC	16	fl oz/a	AB	0 a	1 a	0 c	0.3 a	1.8 a	3 a
8	Danitol 2.4 EC	16	fl oz/a	AB	0 a	0 a	0 c	0.3 a	2 a	2.3 a
17	Entrapment FV	0.063	% v/v	AB	0.3 a	1 a	0 c	0.3 a	0.8 a	2 a
21	Vendex	2	lb/a	A	0.3 a	0 a	0 c	0 a	2 a	2 a
15	Allicurb	48	fl oz/a	AB	0 a	1.5 a	0 c	0.3 a	0 a	1.8 a
4	Aza-Direct	3	pt/a	AB	0.3 a	0 a	0.3 bc	0.3 a	1.3 a	1.8 a
18	CinnAcar	45	fl oz/a	ABC	0 a	1 a	0.3 bc	0.3 a	0.3 a	1.8 a
16	Plinazolin	1.6	fl oz/a	AB	0.5 a	0 a	0 c	1.5 a	0 a	1.5 a
20	Wrath	48	fl oz/a	ABC	0.3 a	0.3 a	0.3 bc	0 a	1 a	1.5 a
	Kinetic	0.125	% v/v	ABC						
3	Kanemite 15 SC	31	fl oz/a	AB	0 a	0 a	0.5 bc	0 a	0.8 a	1.3 a
6	Acramite 4sc	16	fl oz/a	AB	0 a	0.5 a	0 c	0.8 a	0 a	1.3 a
12	Miteus	2	pt/a	AB	0.8 a	0.8 a	0 c	0 a	0.5 a	1.3 a
5	Savey 50 DF	6	oz/a	AB	0.5 a	0.3 a	0.5 bc	0.3 a	0 a	1 a
11	Zeal	3	oz/a	AB	0.5 a	0.8 a	0 c	0 a	0.2 a	1 a
13	Magister	36	fl oz/a	AB	0.5 a	0 a	0 c	0 a	0.8 a	0.8 a
LSD P=.10					0.83	2.56	0.84	1.11	2.65	4.35
Treatment Prob(F)					0.5921	0.7518	0.0434	0.1343	0.2328	0.1272

Thrips Efficacy-Trial 2

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

We identified western flower thrips as the pest in this trial. The trial site has very low population to start with, but the pressure eventually reached 5 per sampling in untreated plots at 14 DAA (7 days after application B, 7 DAB). Meanwhile, Aza-Direct+Pyganic program, Assail, Verdepryn, Malathion, Delegate, Success, Sivanto, CinnAcar, and Plinazolin showed significant control of thrips with only 0.8 to 3 counts per plot (Table 4 column 3).

The pressures naturally dropped by 21 DAA (7 days after application C, 7 DAC) with only 0.5 thrips per plot in untreated check, and no further treatment effect was found.

Overall, due to the dominant numbers at 14 DAA, study total dataset showed a similar trend. The untreated plot ended with a total of 5.5 thrips per plot, however, cumulatively Verdepryn, Malathion, and Sivanto resulted in 4, 3.5, and 5.5 total thrips and thus lost their significant control efficacy on study total numbers.

On the other hand, Aza-Direct+Pyganic program had 2.8, Assail had 2.8, Delegate had 3, Success had 2.3, CinnAcar had 2.8, and Plinazolin had only 0.8 total thrips, resulted in 45% to 85% significant cumulative control (Table 4 column 5) over the study total thrips and potentially these are the better options for thrips control in raspberry.

Table 4. ANOVA table for the mean separation of thrips counts for different treatments for trial 2.

Rating Date					7/1/2024		7/8/2024		7/15/2024		7/22/2024			
Rating Type					count		count		count		count		total no 0D	
Rating Unit					#		#		#		#		#	
Sample Size					2 sides		2 sides		2 sides		2 sides		2 sides	
Collection Basis					1 plot		1 plot		1 plot		1 plot		1 plot	
Pest Name					western flower thrips		western flower thrips		western flower thrips		western flower thrips		western flower thrips	
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	1		2		3		4		5	
1	Untreated Check				0	na	0	na	5	a	0.5	a	5.5	a
10	Sivanto	14	fl oz/a	AB	0	na	0	na	2.8	bcd	2.8	a	5.5	a
15	Wrath	32	fl oz/a	ABC	0	na	0	na	4.3	ab	1	a	5.3	ab
	Oroboost	0.13	% v/v	ABC										
9	Exirel	20.5	fl oz/a	ABC	0	na	0	na	3.5	abc	1.3	a	4.8	abc
16	Wrath	48	fl oz/a	ABC	0	na	0	na	3.8	abc	1	a	4.8	abc
	Oroboost	0.13	% v/v	ABC										
3	Rango	1.25	% v/v	ABC	0	na	0	na	3.3	a-d	1.3	a	4.5	a-d
14	Entrapment FV	0.13	% v/v	ABC	0	na	0	na	3.5	abc	0.8	a	4.3	a-d
5	Verdepryn	11	fl oz/a	ABC	0	na	0	na	3	bcd	1	a	4	a-d
13	Beleaf	2.8	oz/a	ABC	0	na	0	na	3.5	abc	0.3	a	3.8	a-d
6	Malathion 8F	2	pt/a	ABC	0	na	0	na	3	bcd	0.5	a	3.5	a-d
7	Delegate WG	6	oz/a	ABC	0	na	0	na	2	cde	1	a	3	b-e
2	Aza-Direct	1.5	pt/a	ABC	0	na	0	na	2.5	b-e	0.3	a	2.8	cde
	Pyganic	1	qt/a	ABC										
4	Assail 30SG	5.3	oz/a	ABC	0	na	0	na	1.5	de	1.3	a	2.8	cde
11	CinnAcar	32	fl oz/a	ABC	0	na	0	na	2	cde	0.8	a	2.8	cde
8	Success	6	fl oz/a	ABC	0	na	0	na	2	cde	0.3	a	2.3	de
12	Plinazolin	3	fl oz/a	ABC	0	na	0	na	0.8	e	0	a	0.8	e
LSD P=.10					.		.		1.93		1.43		2.34	
Treatment Prob(F)					NaN		NaN		0.0723		0.3422		0.0669	

Two-Spotted Spider Mite Biology-Trial 3

Clearly, difference locations showed very different TSSM population biological patterns (Table 5).

Location 1 and 3 started with moderate pressure with 15 and 16 TSSM per 20 sampled leaves on 7/12. The pressured doubled in location 1 to 34 TSSM a week later on 7/19 but dropped to 5 TSSM on 7/26 and 8/2 and back to 13 TSSM on 8/9 and eventually dropped to 0 on 8/16. Location 3's pressure dropped first to 7 and 5 on 7/19 and 7/26 but then climbed rapidly to 38 on 8/2 and further to 127 by 8/9, and eventually dropped to 3 by 8/16.

Meanwhile, location 2, 4, 5, and 6 started with low/none pressure through 7/12 to 7/26 where location 2 eventually reached 19 TSSM by 8/9, location 4 maintained at 8 and 7 TSSM by 8/2 and 8/9, location 5 had no pressure change during the entire study, and location 6 reached 12 TSSM by 8/2. All locations dropped to 0 by 8/16.

Generally, most locations' TSSM pressure peaked at/after 8/2, except location 1 which had an early peak on 7/19. The results can potentially help growers make better precision application decisions.

Table 5. TSSM numbers per 20 raspberry leaves at different rating timings for 6 locations.

	7/12/2024	7/19/2024	7/26/2024	8/2/2024	8/9/2024	8/16/2024
Location 1	15	34	5	5	13	0
Location 2	0	0	1	5	19	0
Location 3	16	7	5	38	127	3
Location 4	8	0	1	8	7	0
Location 5	1	1	2	3	0	0
Location 6	0	2	2	12	0	0

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

Photo 2. Mite assessment in the lab.

Photo 3. Beat sheet method for the thrips assessment.

Project Proposal to WRRC **Proposed Duration:** 2 Years

Project Title: Two-Spotted Spider Mite and Thrips in Raspberry

Principal Investigator: 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: 2024 **Current Year:** 2025 **Terminating Year:** 2025

Total Project Request: Year 1 - $12,495 Year 2 - $15,000

Other Funding Sources: We have submitted a proposal to the Washington Commission on Integrated Pest Management to support the WRRC effort in the amount of $28,000.

Justification and Background: This project has a major expansion of trial objectives.
Thrips. Based on feedback from the industry, there is an interest in an efficacy trial targeting thrips. There is an expectation that there will be a related proposal from Washington State University focusing on thrips biology and identification. Thrips have not historically been considered a pest of consequence in raspberry in Washington. However, we assume that the primary thrips involved is western flower thrips, *Frankliniella occidentalis*, or at least in the genus *Frankliniella*. The damage in 2023 was widespread in northwest Washington and was of great concern to growers and processors of raspberry. Adult thrips are small (about 1-2 mm long at maturity), slender insects with fringed wings. They are generally white when young but brown or black when mature. The larvae are very tiny and difficult to distinguish without magnification. They feed by puncturing plant material, often blossoms, and sucking out the cell contents. Injured blossoms often turn into distorted fruit. When feeding on flowers, affected petals appear stippled or are scarred with brown streaks or spots. When unusually abundant in spring, thrips have been reported to cause blossom blasting. Fruit may be misshapen or distorted. Controls are most effective when applied at flowering; field control is not practical in eliminating thrips present at harvest. Applications at flowering has the additional challenge of applying

insecticides that are safe to pollinators. *The picture to the left shows feeding damage of thrips on the fruit during 2023.* We propose to screen existing registered insecticides and additional unregistered products for efficacy against thrips. An additional complication is that in order to control thrips, applications will be required during bloom time limiting early season to products that are a low risk to pollinators. Many traditional thrip insecticides are not safe to use around bees.

Two-spotted spider mites. Historically, two-spotted spider mites (TSSM) 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) restrict 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. Second, the standard miticide available for use during harvest is Acramite (bifenazate). Growers and crop advisors 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 TSSM 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 were screened for bifenazate resistance as part of this project and all tested positive for presence of resistance to the miticide. This means that reliance on bifenazate should be immediately reduced. New miticides have been registered for raspberry but lack the necessary MRLs to allow for export.

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 1day preharvest intervals and a high level of efficacy. Ideally, new application programs will have longer periods of residual control and be translaminar (products move into the leaf where a reservoir of active ingredient remains for a period of time providing longer control). And more ideally, the products can obtain MRLs in key export markets.

Summary of 2022. Results suggest a potential use of Fujimite, Aza-Direct, Savey, Acramite, Agri-Mek, and Danitol for controlling TSSM in raspberry.

Summary of 2023. Agri-Mek, Fujimite, Kanemite and Acramite were the most effective miticides and provided significant levels of control. While Acramite resistance is likely widespread in Whatcom County raspberries, the frequency of the resistance gene is likely to be highly variable from field to field. At the location of the 2023 trial, mite populations were obviously still susceptible to Acramite. Agri-Mek, Kanemite, and Fujimite are all excellent miticide choices from an efficacy point of view but lack a complete set of MRLs to make them good replacements to Acramite.

Summary of 2024. Magister was the most effective product and it is relatively newly registered on raspberry for control of two spotted mites, followed by Zeal, then Savey and the Miteus, the latter of which is not registered on raspberry. The most effective product for control of thrips was Plinazolin, which is not registered on raspberry, followed by Success, followed by CinnAcar, followed by Assail, followed by a tank mix of Pyganic and Pyganic, followed by Delegate. *Plinazolin is a product that needs to be registered on raspberry.*

The following is a list of conventional miticides registered on raspberry in Washington as of December of 2022: 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 commonly used in tree fruit for dormant applications for control mites, insect eggs, psyllids, and soft bodied insects. To my knowledge this class of products has not been tried in raspberry. We proposed to conduct a third year's work on mites and a second year's work on thrips.

Relationship to WRRC Research Priority: This project directly addresses the WRRC RFP Category "Mite Management" which is 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 the first applications should begin.

Objective 2. Generate data on miticide efficacy against TSSM in raspberry.

Objective 3. Generate data on insecticide efficacy on thrips in 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.

TSSM 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. Applications 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 in 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 screened 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. Applications would follow labeled use patterns or proposed use patterns.

Thrips Efficacy Data. We are still working on the experimental design for this trial, specifically the products to be included in the trial. Insecticides registered on raspberry that are recommended by OSU for thrips control in caneberry include azadiractin, neem, Assail, Verdepryn, Admire Pro, Malathion, Delegate, and Transform. Other products registered on raspberry that have known efficacy against western flower thrips include Agri-Mek, Success, Exirel, Altacor, Sivanto, Actara, and Knack. Pyrethroid insecticides such as Mustang Maxx, bifenthrin, and Danitol are effective against thrips, however they have been shown by Schreiber to flare thrips in other crops. Additionally, pre-bloom and bloom time are key periods for controlling thrips and several of these products should not be used when pollinators are present or during bloom. There are several products that should provide suitable efficacy against thrips based on work that has been done with them on other crops such as potatoes and onions. Use patterns will probably require up to three applications for control.

Anticipated Benefits and Information Transfer:

Our goal is to develop biological information that will allow improved control of mites and thrips, identification of miticides appropriate for registration, submit miticides for registrations via the IR-4 Project and determine how widespread 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 Co-op grower meeting and the Washington Small Fruit Conference.

Budget:	**2025**	**2026**
Salaries	4,500	4,500
Operations	990	990
Travel	650	650
Contract Research*	7,375	7,375
Benefits	1,485	1,485
Total	**$15,000**	**$15,000**

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

2025 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

New Project Proposal **Proposed Duration:** 1 year

Project Title: Spotted Wing Drosophila Control in Raspberry with Sterile Insect Releases

PI: Louis Nottingham
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Co-PI: Alan Schreiber
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Cooperators: Stephanie Games (Agragene)

Year Initiated __2025__ **Current Year** __2025__ **Terminating Year** __2025__

Total Project Request: **Year 1** $13,988

Other funding sources:
Agency Name: Washington Commission on Integrated Pest Management
Amt. Requested: $21,155
Agency Name: Washington Blueberry Commission
Amt. Requested: $23,636

Description: Spotted Wing Drosophila (SWD) is the top pest of Washington's blueberry and red raspberry industries, located in northwestern Washington and eastern Washington. Both crops rely heavily on broad-spectrum insecticides and spinosad to manage SWD, but alternatives to insecticides are needed to provide resilience against changes in pesticide availability and resistance. Sterile insect release (SIR) has been a highly effective method for pest management in other major commodities, including cotton (pink bollworm), apples (codling moth), and livestock (screwworm). Recently, an SIR method to mass produce sterile male SWD was developed and shown to provide effective control in lab situations. Drs. Nottingham (WSU Entomology, Mount Vernon) and Schreiber (ADG) are proposing to evaluate this SIR technique for suppression of SWD in the field. This proof of concept study will utilize field sites with unharvested berry plants (wild blackberry and/or raspberry fields slated for destruction) to measure SIT efficacy, dispersal of sterile flies, and containment of genetic material.

Justification and Background: (400 words maximum)
Spotted Wing Drosophila (SWD) invaded Washington State in 2009 and almost immediately became the top economic pest of raspberries. Conventional growers went from spraying 3-4 insecticides per year, to upwards of 8-12 per year to control SWD alongside other pests. The most effective materials for SWD are pyrethroids, organophosphates, and carbamates, which are

of high concern for resistances development, secondary pest outbreaks, worker safety, and environmental health. Unfortunately, alternatives to insecticides have not demonstrated the efficacy to warrant meaningful commercial adoption.

The IPM tactic sterile insect technique (SIT), sometimes called sterile insect release (SIR), has a long history of effectiveness against various insect pests. SIT drives down pest insect populations in the field via the mass release of sterile (infertile) male insects. Wild females are more likely to encounter sterile males than viable males, so mating success and the overall population are reduced. SIT has been the primary component of many successful pest suppression, and even eradication, programs including screwworm in livestock (Hendrichs and Robinson 2009), pink bollworm in cotton (Walters et al. 2009), medfly in fruit (USDA-APHIS 2014), codling moth in PNW apples (OK-SIR 2024), and navel orange worm in California tree nuts (CDFA 2024).

Fig 1. Diagram of SWD SIT delivery process and materials.

The SIT method for SWD that we intend to test is being developed with the St. Louis based company, Agragene. CRISPR gene editing is used to mass produce sterile SWD males (no females survive) which are released into the field to mate with wild females, resulting in non-viable eggs. In lab trials conducted at the USDA in Corvallis, SWD SIT males released into cages with wild females reduced offspring and damaged fruit to 0. Agragene has also developed a simple protocol and tool for releases, in which CRISPR-edited adults mate and oviposit into media at the Agragene facility, then the media with SIT eggs is sent to consultants or growers in field release box (Fig. 1).

In this proposal, Nottingham and Schreiber propose field release experiments to assess the efficacy of SWD SIT to reduce injury in Washington raspberries. We will also provide data on genetic containment and dispersal of SIT males to progress regulatory approval and improve implementation strategies.

Relationship to other PNW research: One other group in the PNW is performing field releases of sterile SWD, Chris Adams from OSU Hood River in cherries. Additionally, Jana Lee, USDA Corvallis, OR has ongoing research testing efficacy of this technique in laboratory trials.

Relationship to WRRC Research Priority(s):

- Priority 1: Management options for control of the Spotted Wing Drosophila.
    - This project will serve as the initial step in developing a new IPM technology – Sterile Insect Technique (SIT).

Objectives:

1. Measure % reduction in SWD infested fruit from SIT releases compared to areas not treated with SIT.
2. Assess dispersal distance of sterile SWD males.
3. Determine if genetic material from SIT flies is transferred to marketable fruit.

Procedures:

This will be a one year project due to its proof-of-concept nature. We anticipate a new design in 2026 pending approval for commercial releases of sterile males.

Objective 1, Jun – Sep 2025. Prior to research, we will work with Agragene, regulators, and industry to gain sites and corresponding release permits. We will seek at least five release sites in Western Washington and two in Eastern Washington. Because further permitting is needed for SIT releases into marketed fruit, we will primarily seek sites that are not going to be harvested in 2025, such as wild blackberries, experiment station plots, and/or unused commercial plots slated for destruction. Each site will include at least one release site surrounded by sampling sites for berries and SWD adults, and one control plot with at least 200 m separation (Fig. 2). The size and shape of experimental sites will likely vary based on availability, and thus, the number of release zones and sampling sites will also vary to gain adequate coverage.

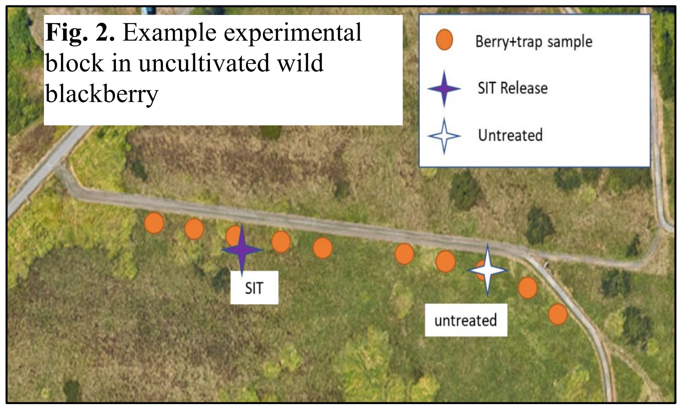

Fig. 2. Example experimental block in uncultivated wild blackberry

Agragene will ship sterile male SWD weekly for releases at no cost. We will begin releases of sterile SWD males into plots at first ripe fruit. Injury will be assessed by collecting 50 berries from three zones at distances of 5-10 m, 30-50 m, and 60-100 m from release and control sites. Should commercial sites become available either due to crop destruction or approval for release into marketed fruit, we will use an alternative experimental design (Fig. 3). Collected berries will be returned to the lab and incubated in mesh cages for 3-5 days, at which point all adults, larvae and pupae will be counted. Fruit material and SWD from samples will be frozen for DNA analysis in Obj. 3.

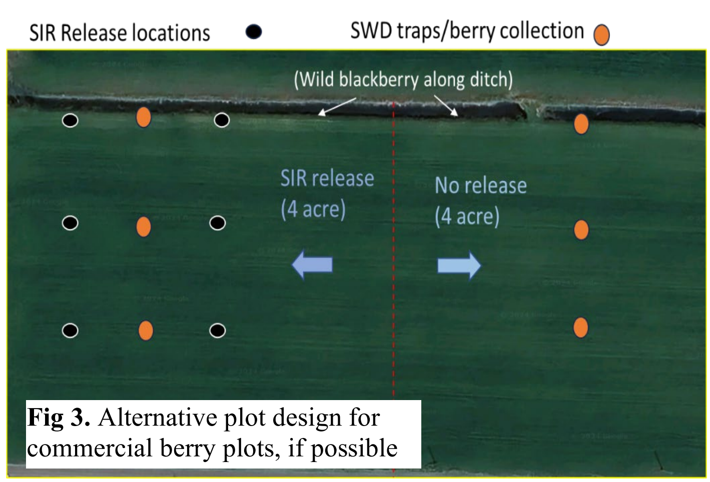

Fig 3. Alternative plot design for commercial berry plots, if possible

Objective 2, Jun – Sep 2025. Each plot will have three SWD jar traps with Scentry lures at 5-10 m, 30-50 m, and 60-100 m from the release site to measure wild SWD population densities and estimate dispersal distance of sterile SWD. Captured SWD will be sent to Agragene for molecular identification of SIT males.

Objective 3, Jun – Sep 2025. Berries and reared SWD from Obj. 1 will be frozen and shipped to Agragene for analysis to determine if molecular material is detected in fruit or in developing SWD progeny. While it is highly unlikely that genetic drift occurs from SIT males into wild populations or fruit, it is important to demonstrate this to regulatory agencies.

Anticipated Benefits and Information Transfer: (100 words maximum)
SWD is the number one pest of Washington blueberry and raspberry growers, as demonstrated by its consistent top ranking in WBC and WRRC priorities. There is critical need for non-insecticidal tactics for SWD in order to slow resistance and prepare for further restrictions on insecticides. Testing sterile insect technique (SIT) in Washington raspberries will help develop the strategy for successful implementation and provide important data on its safety and efficacy to help gain regulatory approval. Results will be shared directly with industry members through reports and extension presentations for the initial year of testing.

References:

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Hendrichs, J., and A. Robinson. 2009. Chapter 243 - Sterile Insect Technique, pp. 953-957. In V. H. Resh and R. T. Cardé (eds.), Encyclopedia of Insects (Second Edition). Academic Press, San Diego.

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USDA-APHIS. 2014. Mediterranean fruit fly preventive release program. https://www.aphis.usda.gov/plant_health/plant_pest_info/fruit_flies/downloads/2014-medfly-prp-review.pdf. Accessed: 11/6/2024.

Walters, M. L., R. Sequeira, R. Staten, O. El-Lissy, N. Moses-Gonzales, E. Radcliffe, W. Hutchison, and R. Cancelado. 2009. Eradication: strategies and tactics. Integrated Pest Management: 298-308.

Budget:

	2025
Salaries[1/]	$5,759
Other[2/]	$6,000
Benefits[3/]	$2,229
Total	**$13,988**

Budget Justification
[1/]PI WSU Assistant Professor (Nottingham) 1% FTE; WSU Technician (Diehl) 15%.
[2/]Co-PI Agricultural Development Group (Schreiber)
[3/] Benefits: Nottingham 27.9%, Deihl, 41.5%

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
	Current:				
DeVetter	USDA NIFA SCRI	7,998,384	9/2022-10/2026	5	Improving End-of-Life Management of Plastic Mulch in Strawberry Systems
Nottingham	WA Commission on Integrated Pest Management	14,388	2024	5	Biology and Management of Maggots Attacking Spinach Grown for Seed
Nottingham	NW Agricultural Research Foundation	28,267	2024	5	Biology and Management of Maggots Attacking Spinach Grown for Seed
Reitz	Northwest Potato Research Consortium	80,872	2023- 2024	5	Managing Insect Pests without Neonicotinoids, Pyrethroids and Organophosphates
Louis Nottingham	WA Blueberry Commission	14,280	2024	5	New Integrated Pest Management Strategies for Blueberries
Louis Nottingham	WA Commission on Integrated Pest Management	13,527	2024	5	New Integrated Pest Management Strategies for Blueberries
Mattupalli	WSDA	249,994	2024-2027	5	Aerial imaging and insect monitoring to study viruses impacting blueberries in northwestern Washington
Serrano	WSDA	245,364	2024-2027	5	Sustainable management of wireworms by targeting the adult click beetles

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.
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Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
	Pending:				
Nottingham	WA Blueberry Commission	23,636	2025	5	Spotted Wing Drosophila Control with Sterile Insect Releases
Nottingham	WA Commission on IPM	21,155	2025	5	Spotted Wing Drosophila Control with Sterile Insect Releases
Nottingham	NARF	24,316	2025	5	Managing *Delia* spp. root maggots in spinach seed crops in the PNW
Nottingham	NARF	24,316	2025	5	Introducing new herbicides to seed production in Washington State
Nottingham	WCIPM	17,468	2025	5	Managing *Delia* spp. root maggots in spinach seed crops in the PNW
Nottingham	WCIPM	17,468	2025	5	Introducing new herbicides to seed production in Washington State

Project Proposal to WRRC **Proposed Duration:** 2 Years

Project Title: Monitoring Raspberry SWD Populations for Insecticide Resistance

Principal Investigator: 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

Cooperator: Louis Nottingham, WSU Mt Vernon Research and Extension Center

Year Initiated: 2024 **Current Year:** 2025 **Terminating Year:** 2025

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

Other Funding Sources: None but there is a parallel research project submitted to the Washington Blueberry Commission. 2024 was the first year of this project. It was funded by the WBC and the WCIPM at the level of $40,000, proposed funding for blueberries in 2025 is $30,000.

Justification and Background: Spotted wing Drosophila (SWD) appeared in Washington in 2009 and quickly became the most critical pest of berries. Initially the pest swamped the ability of growers to control the pest. Eventually growers learned to control the pest through the heretofore unheard of levels of insecticide applications to blueberry and raspberry. A typical conventional SWD program will have six applications of insecticides. The specter of resistance looms larger in raspberry due to the more susceptible nature of the pest and the few insecticides registered for use on the crop.

There is zero tolerance for the presence of SWD in raspberry fruit. A single detection can result in a semi load of the crop being rejected. Raspberry growers producing for the export market face tremendous pressure to have no SWD in their fruit. Additionally, growers of berries destined for the export market have very limited selections of products to use due to maximum residue limits (MRLs). Raspberry growers producing for the export markets rely on a limited number of insecticides. Widespread resistance in SWD to spinosad and malathion has been reported in California (Gress and Zalon 2019, Gress and Zalon in review) and to Exirel and deltamethrin in Italy (Civolani et al. 2021). Anecdotal information exists for resistance to Mustang Maxx and other insecticides in berries in California including raspberries.

A national effort exists to screen SWD for resistance to insecticides which has screened SWD populations in California, Florida, Georgia, Maine, Maryland, Michigan, New Jersey, and North Carolina. Washington and Oregon are not included in the survey. A recent effort to screen SWD for insecticide resistance in Washington berries by WSU's Elizabeth Beers was not successful.

A group of small fruit entomologists have developed a standard protocol for monitoring insecticide resistance in SWD. The method is called Rapid Assessment Protocol for Identification of resistance in SWD (RAPID). It uses a single discriminating dose that can easily and quickly test field populations for the presence of resistance genes. The discriminating dose for malathion, methomyl (Lannate), spinetoram (Delegate), spinosad and zeta-cypermethrin (Mustang Maxx) have been developed for use in the test. This method provides results in 24 hours. This effort originated out of a Specialty Crop Research Initiative that seeks to advance the development of sustainable, integrated management strategies for spotted wing drosophila, SWD, based on biology. Schreiber is on the advisory board for the grant. Additionally, Schreiber used a very similar method for monitoring resistance in field populations of insect pests for his Ph.D. dissertation.

WSU's Louis Nottingham and Alan Schreiber successfully proposed to continue to screen organic and conventionally managed SWD populations for insecticide resistance in eastern and western Washington blueberry farms. No one is screening SWD populations in raspberries for resistance. Schreiber proposes to screen SWD populations in raspberry fields from fruit ranches that have the most insecticidally intense programs, at locations with the highest risk for resistance. There is some reason to believe that raspberry populations may be at high risk for development of SWD resistance. First, SWD prefer or can develop easier on raspberry than blueberry. Second, raspberries have access to fewer insecticides than do blueberries and strawberries.

In the first year of the blueberry project, Nottingham and Schreiber had some challenges figuring out how to conduct the resistance screenings and did not survey as many farms as planned. The "bugs" have been worked out of the system and we expect to be able to significantly increase the number of farms that we can sample.

Relationship to WRRC Research Priority: This project directly addresses the WRRC RFP Category *Management options for control of the Spotted Wing Drosophila.*

Objective: – Determine if SWD has developed resistance to major insecticides used for its control.

Procedures: In this project we will follow what is called the Michigan protocol for the RAPID test. The 20 ml scintillation vials will be treated with 1 ml each of five formulated insecticides Malathion 8F, Lannate 2.4LV, Delegate, Entrust 22.5SC, and Mustang Maxx 0.8EC. Recently produced insecticides less than one-year-old will be used in all bioassays. The identical product will be used as is used in the blueberry SWD resistance monitoring. To prepare for treating the vials, insecticides will be dissolved in acetone for malathion, methomyl, and zeta-cypermethrin, or if they will not dissolve in this solvent we will use water with 1% v/v Induce spray adjuvant for spinetoram and spinosad. Ten adult *D. suzukii* flies from a single population will be placed in each vial and re-sealed with the cap. Wherever possible flies will be loaded in a humid environment, ideally >50% relative humidity, to reduce mortality. After 6 h in the vial (8 hours for spinosad), the number of flies that are alive, moribund, or dead will be counted.

The flies will be live trapped from raspberry fields. We plan to start sampling SWD as soon as they can be trapped with sampling continuing through harvest with a biased sampling more towards the end of harvest, when presumably resistant flies would be more prevalent if they are to be detected. It took us a lot of time to figure out the best lure and trapping techniques. With the 2024 knowledge and experience, we should be able to significantly reduce our sampling effort to have an efficient and reliable sampling process.

Anticipated Benefits and Information Transfer:

If SWD is developing tolerance to key insecticides used for its control, it will undermine existing control program. NW Washington berries have the most intensive SWD programs outside of California, where widespread insecticide resistance has developed. This information, hopefully positive data, 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 meetings and the Washington Small Fruit Conference.

Budget:	**2025**	**2026**
Salaries	6,000	6,000
Operations	500	500
Travel	1,500	1,500
Benefits	2,000	2,000
Total	**$10,000**	**$10,000**

A Report to the Washington Red Raspberry Commission

Title: Management of Slugs on Raspberry

Year Initiated: 2023 **Current Year**: 2024 **Terminating Year**: 2025

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: For reasons that are unclear the presence of slug in raspberry has increased recently. 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. 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. However, feeding damage is not the primary cause of economic loss from slugs but rather contamination of finished product.

A number of slug 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.

Slugs have always been a relatively minor 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 (except for 2023) resulting in conditions more favorable to the development of mollusk pests. Growers have started applying more molluscicides, specifically metaldehyde baits. Slugs are not as attracted to baits as are slugs. There are no registered baited pesticides for slugs. 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 the 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 the U.S. Raspberries are harvested every 36 hours and when the machines shake the raspberry plants and slugs fall into the harvested fruit as a contaminant. Slugs 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.

One difference in this proposal from last year's proposal is that the focus has narrowed to only looking at slugs. This was done at the request of the industry

Materials and Methods

Research staff at Agriculture Development Group, Inc. conducted 3 research trials including an insecticidal control efficacy trial 1 (Table 1), an application timing investigation trial 2 (Table 2), and a 3rd trial looked at the perimeter control method (Table 3) for control of slugs in raspberry. The trials were conducted on a commercial raspberry farm located 5 miles northeast of Lynden, WA (Whatcom County). The experimental design for this trial was a RCB with 4 replications and plot sizes of 10ft x 30ft. Applications were made accordingly to individual product labels where Dealine Bullets and GT were applied as band treatments between plant rows on soil surface, Sluggo Slug and Slug Bait was spread around the perimeter of the plot by hand scattering, Cal Duo was applied by hand as banded application.

For trial 1, applications (Table 1) were made on 6/1 (A), 6/15 (B), and 6/29 (C). Due to low slug population, we could not collect direct count data on the slug, as a result, raspberry canopy was assessed for the # of leaves with slug feeding damage per plot on 7/3 and 7/10.

For trial 2, seven insecticides were applied either as an early program or late program (Table 2) where the early program was applied at 5/16 (A) and 5/31 (B), and the late program was applied at 6/1 (B) and 6/15 (C). The same feeding damage ratings were conducted for trial 2 (Table 5) on 7/3 and 7/10.

For trial 3, Deadline Bullets SG was selected as the treatment, and the applications were made on 6/1 (A), 6/15 (B), and 6/29 (C) by the northwest corner of the raspberry field on the edge of 10 last rows and 4 of the rows were rated for feeding damaged leaves from 10 to 40 aways from the edge, 40 to 70 ft aways from the edge, 70 to 100 ft away from the edge, and 100 to 130 ft aways from the edge (Table 6) on 7/3 and 7/10.

Table 1. Treatment list for trial 1 with application codes.

Trt No.	Treatment Type	Treatment Name	Form Type	Rate	Rate Unit	Appl Code	Appl Description
1	CHK	Untreated Check					
2	INSE	Sluggo Slug and Slug Bait	SG	5	lb/a	ABC	A
3	INSE	Durham	SG	10	lb/a	ABC	B-14 days after A
4	INSE	Deadline Bullets	SG	5	lb/a	ABC	C- 14 days after B
5	INSE	Deadline GT	SG	5	lb/a	ABC	
6	INSE	Sluggo Slug and Slug Bait	SG	20	lb/a	ABC	
7	INSE	Sluggo Fest	L	23.5	fl oz/a	ABC	
8	INSE	Stomp Slug	L	96	fl oz/a	ABC	
9	INSE	Deadline Bullets	SG	20	lb/a	ABC	
10	INSE	Or-Cal DUO	SG	20	lb/a	ABC	
11	INSE	AlliCURB MAX	L	0.5	% v/v	ABC	

Table 2. Treatment list for trial 2 with application codes.

Trt No.	Treatment Name	Form Type	Rate	Rate Unit	Appl Code	Appl Description
1	Untreated Check					14 days interval
2	Deadline GT	SG	5	lb/a	AB	start earlier
3	Deadline GT	SG	5	lb/a	CD	start late
4	Sluggo Bait	SG	20	lb/a	AB	start earlier
5	Sluggo Bait	SG	20	lb/a	CD	start late
6	Stomp Slug	L	96	fl oz/a	AB	
7	Stomp Slug	L	96	fl oz/a	CD	
8	Deadline Bullets	SG	20	lb/a	AB	
9	Deadline Bullets	SG	20	lb/a	CD	
10	Or-Cal DUO	SG	20	lb/a	AB	
11	Or-Cal DUO	SG	20	lb/a	CD	
12	Sluggo Fest	L	23.5	fl oz/a	AB	
13	Sluggo Fest	L	23.5	fl oz/a	CD	
14	Durham	SG	10	lb/a	AB	
15	Durham	SG	10	lb/a	CD	

Table 3. Treatment list for trial 3 with application codes.

Trt	Treatment	Form	Rate	Appl	Appl

No.	Name	Type	Description	Rate	Unit	Code	Description
1	Untreated Check						
2	Deadline Bullets	SG	apply perimeter	40	lb/a	ABC	14 day interval

Results and Discussion

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

Insecticide Efficacy-Trial 1

Due to the unexpected low pressure, we did not observe direct slug population on the plants, thus indirect data was collected on # of feeding damaged leaves per plot. Treatment did not exhibit statistical differences among themselves and untreated check on both 7/3 and 7/10. Deadline Bullets and Stomp Slug resulted in relatively lower counts at 8.3 feed damaged leaves per plot.

Insecticide Timing Early VS Late-Trial 2

Similar to trial 1, indirect data was collected on # of feeding damaged leaves per plot. Treatment did not exhibit statistical differences among themselves and untreated check on both 7/3 and 7/10. While there were no observable differences among early A + B application and the late B + C application, under unclear reason, none of the treatments had lower damage ratings than untreated check.

Insecticide Perimeter Application Efficacy-Trial 3

Slug pressure was low in this trial. So low that there was no significant differences between all treatments. There was a trend of more damaged leaves for distance further away from the edge where 70 to 100 ft and 100 ft to 130 ft away from the edge sections had 9.8 and 9.3 damaged leaves, compared to the 8.5 and 5 damaged leaves in sections of 10 to 40 ft and 40 to 70 ft away from the edge. There was no obvious trend in the dataset from July 3.

Table 4. ANOVA table for the mean separation of damaged leaves per plot for different treatments in trial 1.

Rating Date					7/3/2024		7/10/2024	
SE Description					# of feed damaged leaves		# of feed damaged leaves	
Rating Type					Count		count	
Rating Unit					#		#	
Days After First/Last Applic.					32, 7		39, 14	
Trt	Treatment		Rate	Appl				
No.	Name	Rate	Unit	Code				
11	AlliCURB MAX	0.5	% v/v	ABC	4.3	a	13.0	a
5	Deadline GT	5	lb/a	ABC	3.8	a	12.3	a
2	Sluggo Slug and Snail Bait	5	lb/a	ABC	6.0	a	11.3	a
6	Sluggo Slug and Snail Bait	20	lb/a	ABC	3.8	a	11.3	a
3	Durham	10	lb/a	ABC	2.8	a	10.3	a
1	Untreated Check				5.3	a	10.0	a
10	Or-Cal DUO	20	lb/a	ABC	5.0	a	9.5	a
7	Sluggo Fest	24	fl oz/a	ABC	3.8	a	9.0	a
9	Deadline Bullets	20	lb/a	ABC	2.5	a	9.0	a
4	Deadline Bullets	5	lb/a	ABC	4.0	a	8.3	a
8	Stomp Slug	96	fl oz/a	ABC	3.5	a	8.3	a
LSD P=.10					2.32		3.52	
Treatment Prob(F)					0.3518		0.3467	

Table 5. ANOVA table for the mean separation of damaged leaves per plot for different treatments in trial 2.

Rating Date					7/3/2024		7/10/2024	
SE Description					# of feed damaged leaves		# of feed damaged leaves	
Rating Type					count		Count	
Rating Unit					#		#	
Trt	Treatment		Rate	Appl				
No.	Name	Rate	Unit	Code				
14	Durham	10	lb/a	AB	4.0	a	12.8	a
15	Durham	10	lb/a	BC	4.8	a	11.8	ab
9	Deadline Bullets	20	lb/a	BC	2.3	a	11.0	abc
3	Deadline GT	5	lb/a	BC	5.0	a	10.8	a-d
12	Sluggo Fest	24	fl oz/a	AB	5.8	a	10.5	a-d
10	Or-Cal DUO	20	lb/a	AB	4.3	a	10.3	a-e
2	Deadline GT	5	lb/a	AB	7.0	a	9.8	b-f
5	Sluggo Bait	20	lb/a	BC	5.0	a	9.3	b-g
8	Deadline Bullets	20	lb/a	AB	3.8	a	9.3	b-g
11	Or-Cal DUO	20	lb/a	BC	4.3	a	9.0	c-g
4	Sluggo Bait	20	lb/a	AB	2.5	a	8.3	d-g
13	Sluggo Fest	24	fl oz/a	BC	4.5	a	8.3	d-g
6	Stomp Slug	96	fl oz/a	AB	7.3	a	7.8	efg
7	Stomp Slug	96	fl oz/a	BC	3.5	a	7.3	fg
1	Untreated Check				4.0	a	6.8	g
LSD P=.10					4.13		2.74	
Treatment Prob(F)					0.813		0.0265	

Table 6. ANOVA table for the mean separation of damaged leaves per plot for different distance aways from the edge in trial 3.

Rating Date					7/3/2024	7/3/2024	7/3/2024	7/3/2024	7/10/2024	7/10/2024	7/10/2024	7/10/2024
SE Description					feed damaged leaves	feed damaged leaves	feed damaged leaves	feed damaged leaves	feed damaged leaves	feed damaged leaves	feed damaged leaves	feed damaged leaves
Rating Type					count	count	count	count	count	count	count	count
Rating Unit					#	#	#	#	#	#	#	#
Days After First/Last Applic.					32, 4	32, 4	32, 4	32, 4	39, 11	39, 11	39, 11	39, 11
Description					10 to 40 ft from edge	40 to 70 ft from edge	70 to 100 ft from edge	100 to 130 ft from edge	10 to 40 ft from edge	40 to 70 ft from edge	70 to 100 ft from edge	100 to 130 ft from edge
Trt	Treatment		Rate	Appl								
No.	Name	Rate	Unit	Code								
1	Deadline Bullets	40	lb/a	ABC	2.3	1.8	2.5	1.5	8.5	5.0	9.8	9.3

WEEDS

Washington Red Raspberry Commission Research Report

Title: Spot Spraying of Raspberry Herbicides

Year Initiated: 2023 **Current Year:** 2024 **Terminating Year:** 2024

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Take Home Message

Spot spray technology:

- Did not reduce herbicide use during caneburning applications in two of three trials.
- Reduced herbicide use in both pre-harvest trials.
- Reduced herbicide use in one of two post-harvest trials.
- In all seven trials in 2024, reduced weed density and biomass as effectively as broadcasted herbicides.

Background

Red raspberries are not very competitive with weeds and require effective weed management strategies that are not economically feasible. Weed distribution within a red raspberry field can: a.) be relatively uniform, b.) be in patches of single weed species, c.) be in patches of multiple weed species, or d.) a combination of B and C. To remove weeds, producers rely on the use of backpack sprayers with postemergence herbicides, hand-weeding crews, or a combination of both.

The cost of herbicides is estimated at $112 per acre; and application takes about an hour per acre, amounting to $28 per acre. Labor costs comprise 51% of the total variable costs per year, on average, in producing red raspberries in western Washington, considering a 6-year life of raspberry planting. Total labor costs associated with herbicide application (spot and split spraying) is estimated at 0.48% of total variable costs per year, on average, over the same period [1]. For 2024, the Adverse Effect Wage Rates (AEWR) in Washington State are $19.25/hour, which, together with Oregon, is the second highest rate in the U.S., only following California. The 2024 minimum wage in the state is $16.28 per hour, which is also the second highest in the country. These wage rates are higher by about 7% and 3%, respectively compared to 2023 rates. Farm operators normally pay more than these base rates plus benefits to maintain their group of dependable workers throughout the growing season.

On November 5, 2020 the Washington State Supreme Court passed a ruling requiring dairy farms to pay workers overtime for work beyond 40 hrs./week [4]. Although it directly applies to one industry, the language of the ruling is commonly expected to be extended to the rest of the agriculture industry. Farms already face increasing labor costs, even without this ruling, due to a shortage of farm workers, which only worsened due to the COVID-19 pandemic. Red raspberry farms are not exempt from this situation.

Weed management is labor-intensive as it relates to non-uniform distribution of weeds within fields. While several factors determine the profitability of red raspberry production, it is worthwhile to look into 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[5] with major advances during this time period[6]. These systems can reduce the need for labor, and herbicide costs, and are increasingly used to manage herbicide-resistant weeds[7]. Though the use of this technology has not been evaluated in raspberry production systems.

Sensor sprayer technology does have drawbacks such as initial capital cost, limitations in certain cropping systems, and mechanical limitations in early versions. Systems vary with some having the capacity to distinguish weeds from the crop and others can identify individual weed species. Ultimately, the economic benefit of reduced production costs (labor and herbicides) resulting from spot spray technology is based on the density of weeds, species present, and size of weeds. As weed density increases, a threshold will be overcome to justify a broadcast application. No economic analysis exists utilizing associated costs from this production system that would allow for a red raspberry producer to make an educated decision related to considering spot spray technology. This project is designed to be completed over multiple years with two major phases (Fig. 1).

Figure 1. Timeline of the phases to evaluate spot spray technology in Northwest Washington raspberry fields.

Objectives:

Objective 1. 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 2. Evaluate the use of spot spray technology for use in red raspberries in western Washington in terms of efficacy and efficiency. (2023-2024)

2024 Methods

Field Trials with Spot Sprayer

Eight trials were set up in two 'Meeker', one 'Kulshan', and one 'Wakefield plantings with trial details included in Table 1. The 'Kulshan' trial was terminated early. Six of the trials occurred pre-harvest and two post-harvest. Trials were situated in commercial raspberry fields consisting of three post lengths, at least four replications per treatment, and set up in a randomized complete block design. Herbicide and surfactant selections and application timings were based on what choices and activities were occurring in the adjacent commercial fields. Treatments consisted of 1.) broadcast herbicide or 2.) spot spray herbicide and was applied at 1 pint/A (20 PSI, 52 GPA) using a custom CO_2 sprayer mounted onto a

Farmall Cub tractor fitted with a Weed-It Quadro spray system (Fig. 2). Herbicide was mixed with water and spray dye in 3 L plastic bottles and total herbicide applied was determined by measuring all remaining product for each plot.

Table 1. Details of spot spray trials in red raspberries, Washington State.

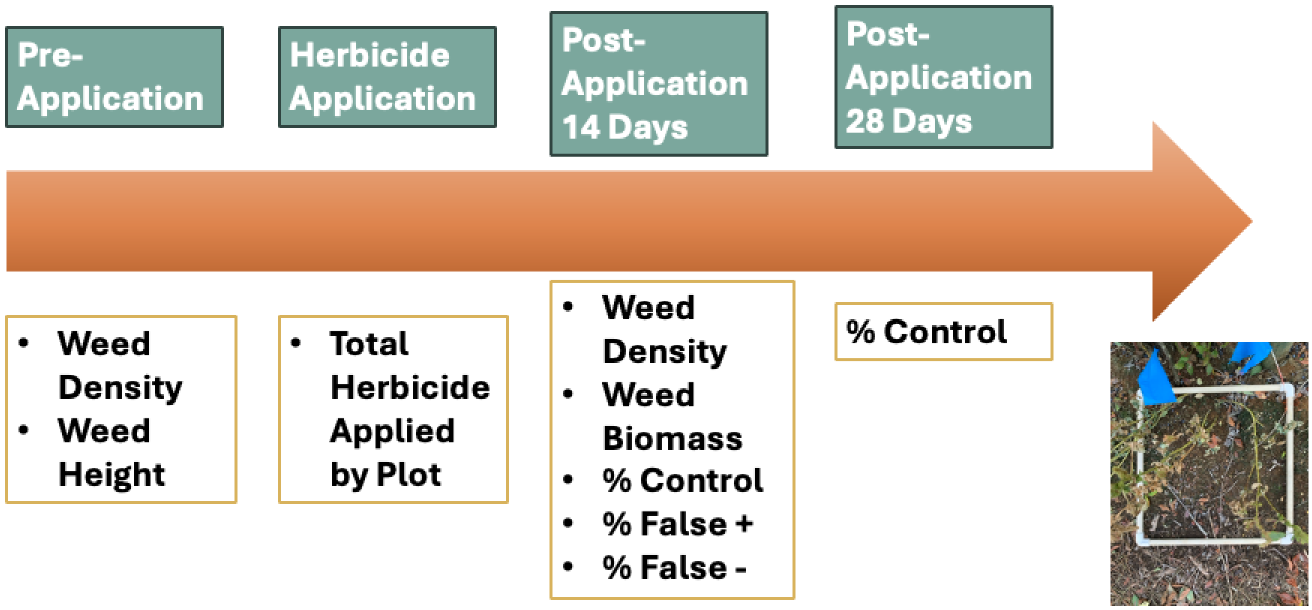
Trial	Farm	Variety	Trial Date	Herbicide 1	Herbicide 2	Herbicide 3	Surfactant	GPA
1	1	'Meeker'	4/6/24	paraquat 1 pt/A	carfentrazone 2 oz/A		NIS	52
2	1	'Meeker'	4/6/24	paraquat 1 pt/A	carfentrazone 2 oz/A		NIS	52
3	2	'Wakefield'	4/16/24	paraquat 1 pt/A	carfentrazone 2 oz/A	diuron 1.75 pt/A	polyacrylamide	100
4	1	'Meeker'	5/14/24	paraquat 1 pt/A	carfentrazone 2 oz/A	sulfentrazone 3 oz/A	NIS	52
5	1	'Meeker'	5/14/24	paraquat 1 pt/A	carfentrazone 2 oz/A	sulfentrazone 3 oz/A	NIS	52
6	1	'Meeker'	8/14/24	paraquat 1 pt/A			NIS	52
7	1	'Meeker'	8/14/24	paraquat 1 pt/A			NIS	52

Figure 2. Weed-It Quadro Spray System.

Weed Assessments

Weed density (by species) and height were quantified the day prior to herbicide applications by placing two ¼ m^2 quadrats randomly in raspberry rows for each treatment and replication. Those locations were flagged and marked with field paint as well as geolocated with a GPS unit. Fourteen days after application weeds were counted again and biomass samples taken. Samples were weighed, then dried in an oven (35°C) for one week, and then weighed again. Additionally, two X 6 m areas within each plot were marked with flags and field paint. These areas were used to provide a visual assessment of 1.) percent control at 14 days after application, 2.) percent weed leaf area that did not receive herbicide (false negative), 3.) percent of soil that erroneously received herbicide (false positive), and 4.) percent control at 28 days after application (Fig. 3).

Figure 3. Methods utilized for all spot spray trials in red raspberries, 2024.



Economic Analysis

Herbicide costs have been collected from the field studies for the broadcast (baseline) and spot spray treatment (alternative). The costs of the alternative were compared to those of the baseline to find out if there are any cost savings. The three scenarios of herbicide cost savings are used in the analysis – 21%, 54% and 71% based on actual field trials over the last couple of years. The latest 'Meeker' enterprise budget (Galinato et al. 2023) was also used to derive the potential cost savings per acre (if any) if the alternative was adopted.

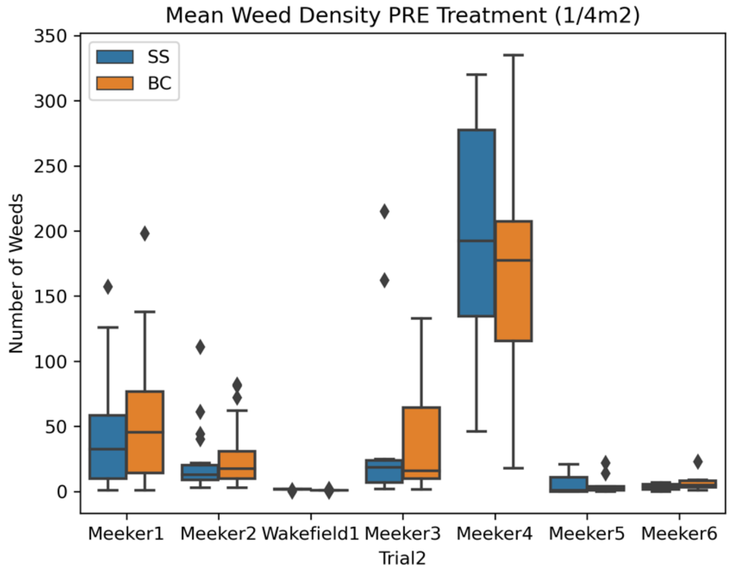
Results

Field Trials with Spot Sprayer

Weed Assessments

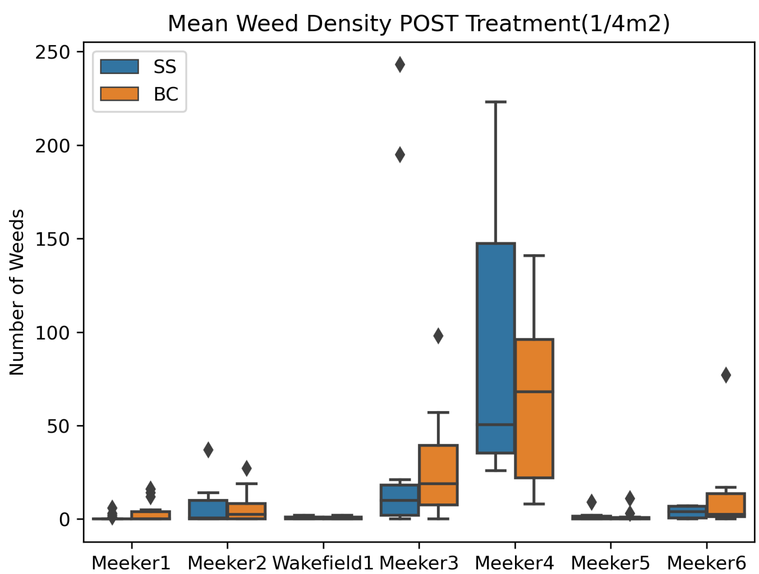
Weed density prior to herbicide application were similar across treatments for both trials (Fig. 4). Despite some notable outliers, 14 days after herbicide application both weed density and weed biomass was similar between treatments (Fig. 5 & 6). Visual control assessments from larger areas of the plots found similar effectiveness between treatments at 14 days after treatment and 28 days after treatment (not shown for brevity). Control ratings averaged >80% across these two assessment periods and while acceptable, herbicide application to weeds was hindered by primocane presence during this time of year (this was not affiliated with a specific treatment).

Figure 4. Weed density (1/4 m^2) ***before*** herbicide treatment in raspberries (seven trials), 2024.



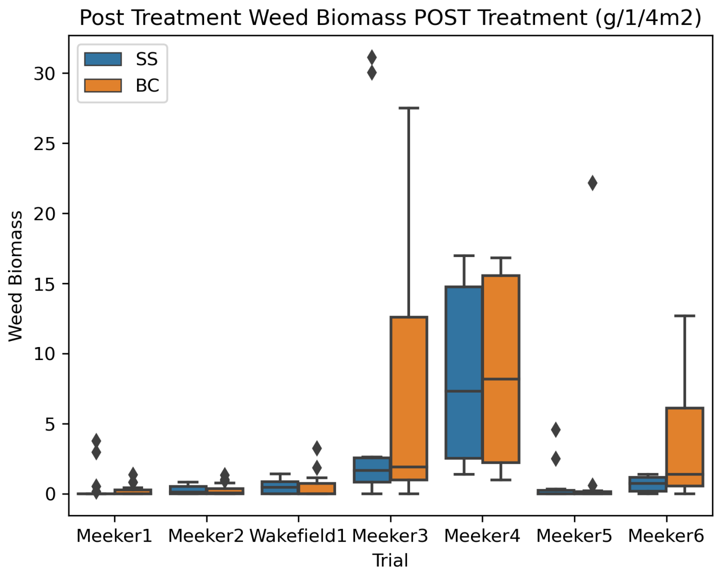
SS=Spot spray treatment
BC = Broadcast treatment

Figure 5. Mean weed density (1/4m^2) 14 days ***after*** herbicide treatment in raspberries (seven trials), 2024.



SS=Spot spray treatment
BC = Broadcast treatment

Figure 6. Weed biomass (g/1/4m^2) 14 days ***after*** herbicide treatment in raspberries (seven trials), 2024.

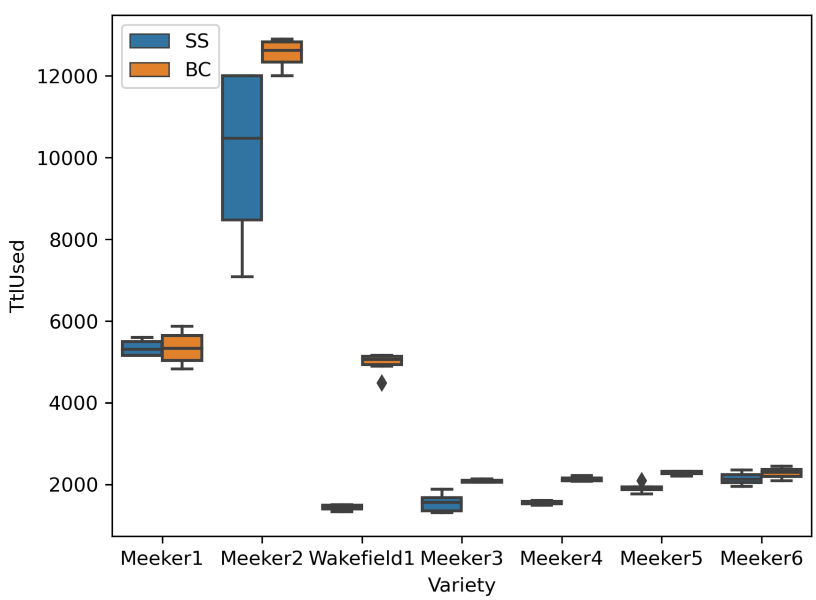


SS=Spot spray treatment
BC = Broadcast treatment

Herbicide Application

Early spring trials were initiated during caneburning activities, and the spot sprayer did not reduce the total amount of herbicide applied in two of three trials (Fig. 7). The dense primocanes constantly triggered the solenoids resulting in similar herbicide use. However, the spot sprayer reduced total herbicide use significantly in both pre-harvest trials. In one of the two post-harvest trials, the spot sprayer reduced overall herbicide use.

Figure 7. Total herbicide applied (ml/plot) in red raspberries for spot spray and broadcast treatments, 2024. Each trial (e.g. 'Meeker1') is analyzed separately.



SS=Spot spray treatment

BC = Broadcast treatment

Economic Analysis
The results from the field trials showed that multiple spot spray applications are cheaper, in terms of herbicide costs, than a single broadcast (Fig. 8). The three herbicide reduction scenarios – 21%, 54% and 71% are based on field trials in the past two years. When these scenarios are adopted for 'Meeker', a grower can potentially save $24 to $80 per acre per year or about $706 to $2,386 per year given 30 acres of production area. This estimate is based on the cost savings for 'Meeker' and the baseline of $112/acre per year of herbicide costs in the enterprise budget (Galinato and Gallardo, 2023). Additionally, the spot spray equipment cost is about $11,910. The purchase cost of the equipment will be repaid in about 5 to 17 years, depending on the expected herbicide cost savings (Table 1).

Figure 8. Herbicide costs outlined in four scenarios: 1.) broadcast herbicide, 2.) spot sprayer @21% reduction in herbicides, 3.) spot sprayer @54% reduction in herbicides, 4.) spot sprayer @71% reduction in herbicides.

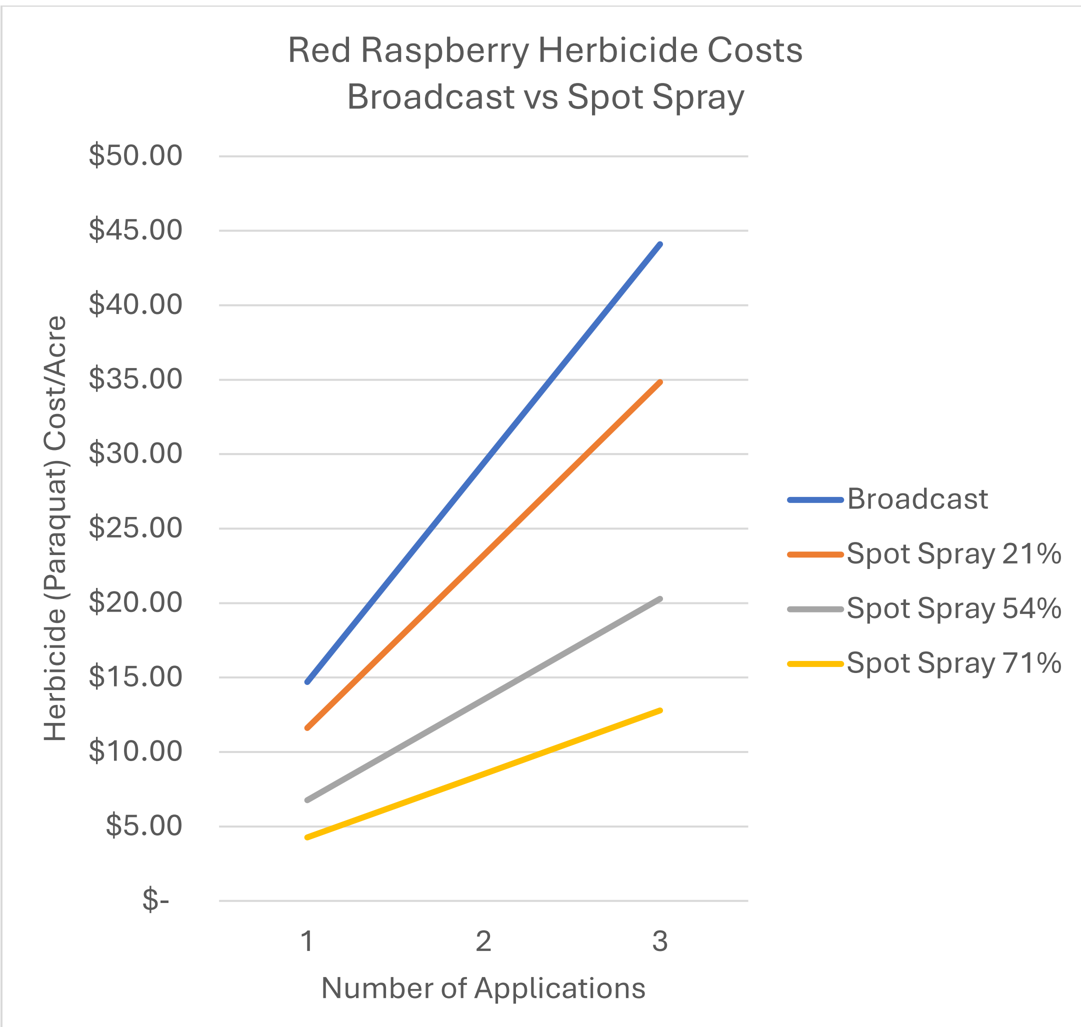


Table 1. Initial cost, potential savings, and payback period of spot spray equipment.

Variable	Different reductions in herbicide costs (% lower than base)		
	21%	54%	71%
Initial cost	$11,910	$11,910	$11,910
Annual savings	$706	$1,814	$2,386
Simple payback period (years)*	**16.88**	**6.56**	**4.99**

Notes:
Baseline herbicide costs = ($3,360 per year for 30 acres).
*The estimate of the payback period assumes that the herbicide products in one trial are applied in the exact way (i.e., same amounts) multiple times in the year and the total number of applications is the same as in the baseline. Simple payback period is calculated as initial cost divided by annual savings.

Conclusion and Additional Thoughts

Spot spray technology did reduce herbicide use in several trials under several application timings. It is clear though this technology could only supplement traditional broadcast herbicide applications under heavy weed pressure or during caneburning activities when the spot sprayer would be constantly triggered thus reducing the justification of equipment purchase. As regulations evolve to favor the use of such equipment under specific scenarios, purchasing the equipment might be further justified outside of the scope of this project. Future research could focus on applying multiple products simultaneously in precise application zones, application of herbicides with mixed (pre & post) activities, and as part of larger herbicide screens. Additionally, future economic analysis will include the estimation of payback periods given different scales of farm operation and results will be reported in journal publications and outreach materials, like Extension bulletins.

References:

1. Galinato, S., Gallardo, R. K. & Hong, Y. A. 2015 Cost Estimates of Establishing and Producing Conventional Highbush Blueberries in Western Washington. *Wash. State Univ. Ext.* **TB36**, 11 (2016).
2. H-2A Adverse Effect Wage Rates (AEWRs) | Flag.dol.gov. *DOL (Department of Labor)* https://flag.dol.gov/wage-data/adverse-effect-wage-rates.
3. State Minimum Wage Laws. https://www.dol.gov/agencies/whd/minimum-wage/state.
4. Jenkins, D. Washington high court alters state's agriculture industry. *Capital Press* https://www.capitalpress.com/ag_sectors/dairy/washington-high-court-alters-states-agriculture-industry/article_08d77088-1fb6-11eb-a555-63d730301c7f.html (2020).
5. Steward, B. L. & Tian, L. F. Real-Time Machine Vision Weed-Sensing. in *Paper No. 983033* (1998).
6. Piron, A., Heijden, F. & Destain, M. Weed detection in 3D images. *Precis. Agric.* **12**, 607–622 (2011).
7. Cook, T. Weed detecting technology: an excellent opportunity for advanced glyphosate resistance management. *Dev. Solut. Evol. Weed Probl. 18th Australas. Weeds Conf. Melb. Vic. Aust. 8-11 Oct. 2012* 245–247 (2012).

2025 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

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

Project Title: Management of weeds in the Polygonaceae family in raspberries

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Year Initiated 2025 **Current Year** 2025 **Terminating Year** 2026

Total Project Request: **Year 1 $** 9272 **Year 2 $** 8672 **Year 3 $**

Other funding sources:
Agency Name: Washington Commission on Integrated Pest Management
Amt. Requested/Awarded: $9272

Description:
Over the past decade, weeds in the Polygonaceae family such as ladysthumb (*Polygonum persicaria*), wild buckwheat (*Fallopia convolvulus* L.), and pale smartweed (*Persicaria lapathifolia* L.) have become increasingly more common in red raspberry fields. This project has two objectives: 1.) Evaluate the effectiveness of herbicides currently registered for raspberries to manage weeds in the Polygonaceae family, and 2.) Evaluate the effectiveness of a degree day model to properly time post-emergent herbicide applications. The outcomes of this project will be improved knowledge of these weeds (1 year), identified herbicide programs for management (2-3 years), and reduced presence of these weeds in red raspberry fields (5+ years).

Justification and Background:
Red raspberries in Northwest Washington are largely grown in one county and represent the far majority (~90%) of US processed raspberry fruit. Weeds compete with raspberries for water, nutrients, space, and light, cause yield reductions, and can indirectly degrade fruit quality. Weeds are largely managed through the application of pre- and post-emergent herbicides applied as a broadcast over the entire raspberry hill or along hill edges (“skirting”). The industry typically grows one of six varieties, all of which are floricane fruiting types. Because of this, in a given growing season, growers must manage both the fruiting (floricane, 2-year-old wood) and vegetative (primocane, one-year-old) canes. The first flush of primocanes is typically chemically removed

("cane burning"), but the second flush is allowed to grow up into the canopy alongside the floricanes. During this time, herbicides cannot be used as they would have a negative impact on the growing primocanes. This period is also a time when air and soil temperatures are increasing, and weed emergence and growth are rapid. Additionally, most raspberry harvest occurs over a ~six-week period when most growers also do not typically apply herbicides.

Over the past decade, growers have reported an increase in three weeds (*Persicaria maculosa*, *Polygonum aviculare, Fallopia convolvulus)* in the Polygonaceae family. Two of these weeds have prostrate or tailing growth habits that can intertwine within the raspberry plant canopy. In some cases, even if post-emergent herbicides are applied, the plant continues to mature and shed seed. As a result, growers need better information about applying currently registered herbicides at the time when the impact on these weeds will be most effective. Growing degree day models (GDD) can accurately predict the presence of pests and, more specifically, the flowering of weeds[1]. Seefeldt and Benedict[2] developed a GDD for the development of four key Polygonaceae weeds in Northwestern Washington. This model identified the timing for effective herbicide applications to manage these weeds but has yet to be tested under commercial conditions.

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

Objectives:

1. Evaluate the effectiveness of herbicides currently registered for raspberries to manage weeds in the Polygonaceae family.
2. Evaluate the effectiveness of a degree day model to properly time post-emergent herbicide applications.

This project is planned for two field seasons and is targeted to be completed in 2026.

Procedures:

Herbicide Efficacy (Obj. 1)

One field in Whatcom County with a high population of ladysthumb, prostrate knotweed, and wild buckwheat will be utilized. In 2024 the location of individual plants was noted using a centimeter-accurate GPS (Trimble, Westminster, CO). Plots will be 20'X5', contain at least one target weed, and each treatment will be replicated five times and setup in a randomized complete block design. Herbicides will be broadcast using a CO_2 sprayer (22 PSI, 52 GPA). Additionally, a weed-free control will be included, and all hand-weeding activities will be recorded. One trial will focus on pre-harvest suppression and a separate trial will focus on post-harvest management. Herbicides will consist of currently registered products.

Weed density and height will be quantified the day before herbicide applications by placing two ¼ m^2 quadrants randomly in raspberry rows for each replication. These locations will be flagged and marked with field paint as well as geolocated with a GPS unit. Fourteen days after application, weeds will be counted again. Additionally, two X 2 m areas within the row will be marked with flags and field paint. These areas will be used to provide a visual assessment of 1.) percent control and damage to raspberries at 14 days after application, and 2.) percent control and damage to raspberries at 28 days after each application.

Herbicide Timing (Obj. 2)

Using the growing degree day (GDD) model developed by Seefeldt and Benedict (2020), paraquat (Gramoxone SL 3.0, Syngenta, Greensboro, NC) will be applied at 4 pts/A (22 PSI, 52 GPA) using a backpack CO_2 sprayer system. Applications will occur at various leaf stages (2, 3, 4 leaf), timing determined by a GDD model, and all compared to a handweeded control. Plots will be 20'X5' and each treatment will be replicated five times setup in a randomized complete block design.

Plots will be visually assessed for suppression of polygonum weeds at 14- and 28-days after treatment and then again before harvest. Additionally, before herbicide application individual weeds will be identified and flagged. These plants will then be assessed for growth, maturity, and seed production throughout the course of the growing season.

Results from the trials will be summarized in a report for the Commission and circulated in the WSU newsletter Whatcom Ag Monthly. Additionally, results will be shared with the berry industry at the Lynden AG Show and WA Small Fruit Conference in December 2025.

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. This project will identify effective herbicides to suppress Polygonaceae weeds and the proper application timing for post-emergent herbicides. This will result in reduced pressure and seed production of these weeds in raspberry fields. Additionally, raspberry producers will be able to make better-informed decisions as to when to apply herbicide to maximize impact on weeds. Results from this project will be posted in WSU's Whatcom Ag Monthly newsletter as well as presented at the Lynden AG Show.

References:

1. White, S. N., Boyd, N. S. & Acker, R. C. V. Temperature Thresholds and Growing-Degree-Day Models for Red Sorrel (Rumex acetosella) Ramet Sprouting, Emergence, and Flowering in Wild Blueberry. *Weed Sci.* **63**, 254–263 (2015).
2. Seefeldt, S. & Benedict, C. *Integrated Pest Management of Annual Polygonum Species in Northwest Washington Specialty Crops: Working with Plant Biology*. (2020).

Budget:

	2025	2026	2027
Salaries[1/]	$2669	$	$
Time-Slip	$3264	$	$
Operations (goods & services)	$1740	$	$
Travel[2/]	$469	$	$
Meetings	$0	$	$
Other	$0	$	$
Equipment[3/]	$0	$	$
Benefits[4/]	$1130	$	$
Total	**$**9272	**$**	**$**

Budget Justification

[1/]Faculty, 2% FTE, 12 months $2669

[2/]Travel to and from research sites. 700 miles @ $0.67/mile

[3/]None

[4/] Faculty @ 30% $801, Timeslip 10.1% $329

A Report to the Washington Red Raspberry Commission

Title: Management of Grass Weed in Raspberry

Year Initiated: 2023 **Current Year**: 2024 **Terminating Year**: 2025

Principal Investigator:
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Justification and Background: Perennial and annual grassy weeds are a serious pest of raspberries. The industry had a Section 18 for several years for Chateau (flumioxazin) on Reed canary grass and quackgrass. The registrant stopped supporting the Section 18 and this use pattern was lost. There are a number of herbicides that have some potential to manage grassy weeds but due to various use restrictions, supply change issues, regulatory problem and phytotoxicity, there are no good means to control perennial grasses in raspberry. Poa annua (bluegrass) is also a problem. Roundup can control the weeds but raspberry is highly sensitive to the active ingredients and growers are highly reluctant to use the product. There are a number of 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 leading to weed seeds germination. 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. Berry growers are a litigious group and have sued (one grower in Skagit County is suing over an herbicide application currently) over herbicide related damages. Despite being sued over the use of sulfentrazone on raspberry, a prominent berry crop advisor in Whatcom County, out of desperation will apply the herbicide on the edge of the hill in an effort to control weeds. Surflan is no longer available.

Growers are seeking for 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 quack grass, is not very good. Ideally, the growers would like to have Chateau herbicide.

The WRRC plans to conduct a set of herbicide trials that will screen new herbicides against grasses in raspberry, attempt to use some existing herbicides with different timings and use some new application technology to improve control.

Materials and Methods

Dr. Tom Walters conducted this herbicidal trial for control of grass weeds in raspberry. The trials were conducted on a commercial raspberry farm located 5 miles northeast of Lynden, WA (Whatcom County) and the grower only allowed us to apply Dakota and Liberty as our treatment list (Table 1). The experimental design for this trial was a RCB with 4 replications and plot sizes of 3ft x 25ft. A single application was made on 8/10 (A). The plots were rated on 9/4 for % phytotoxicity on raspberry and % control of grass weeds which was found to be common barnyardgrass in this trial.

Table 1. Treatment list.

Trt No.	Treatment Name	Form Type	Rate	Rate Unit	Appl Code
1	Untreated Check				
2	Dakota	L	8	fl oz/a	A
	COC	L	1	% v/v	A
3	Liberty	L	28	fl oz/a	A

Results and Discussion

Dakota has active ingredient, clethodim, which is a selective grass weed herbicide and showed no phytotoxic impact on raspberry with 0 phytotoxicity by 9/4 (Table 2 Column 1). Meanwhile, Liberty contains glufosinate, a non-selective contact herbicide, we observed unacceptable damage on any contacted area of the raspberry with 55% phytotoxicity (Table 2 Column 2; Photo 1).

With a single application, both herbicides achieved decent control over the common barnyardgrass with 50% control by Dakota and 65% control by Liberty (Photo 2). However, this is a later season application (on 8/10) and the weed size was already >6" before application, thus sequential application would be needed for better control yet more phytotoxicity risks on the raspberry maybe unavoidable.

Table 2. ANOVA table for the mean separation of % phytotoxicity and % weed control.

Rating Date					9/4/2024		9/4/2024	
Rating Type					PHYGEN		control	
Rating Unit					%		%	
Sample Size					1 plot		1 plot	
Crop Name					wild raspberry		wild raspberry	
Pest Name							common barnyardgrass	
Days After First/Last Applic.					25, 25		25, 25	
Trt	Treatment		Rate	Appl	1		2	
No.	Name	Rate	Unit	Code				
1	Untreated Check				0	b	0	c
2	Dakota	8	fl oz/a	A	0	b	50	b
	COC	1	% v/v	A				
3	Liberty	28	fl oz/a	A	5.5	a	65	a
LSD P=.10					0.46		7.93	
Treatment Prob(F)					0.0001		0.0001	

Photo 1. Phytotoxicity on raspberry by Liberty.

Photo 2. Damage on the barnyardgrass by Dakota on the left and Liberty on the right.

2024 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

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

Co-PI: Alan Schreiber
Organization: Agriculture Development Group, Inc.
Title: President
Phone: 509-266-4348
Email: aschreib@centurylink.net
Address: 2621 Ringold Road
City/State/Zip: Eltopia, WA, 99330

Year Initiated: 2023 **Current Year** 2024 **Terminating Year** 2025

Total Project Request: **Year 1** $6,248 **Year 2** $12,495

Other funding sources:
Agency Name: Washington Commission on Pesticide Registration
Amt. Requested/Awarded: $17,955 in 2023, half spent in 2023, half in 2024.

Description:

We propose to conduct a pair of efficacy trials to develop improved methods for control of perennial grassy weeds in raspberry. If successful, this will also have application to annual grassy weeds. This trial was initiated but not completed in 2023. Half of the funds were expended in 2023, and we are requesting the remaining 2023 funds for use in 2024 to complete the trials.

Justification and Background:

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* (annual bluegrass). Roundup can control weeds, but raspberries are highly sensitive to it and growers are very 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, Matrix, Devrinol, Kerb, Solicam, 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. They 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.

This trial was initiated in 2023 but was not completed. We are requesting an extension on this project so the remaining 50% of the 2023 funds can be expended in 2024. Additionally, a parallel extension of funds has been granted by the Washington Commission on Integrated Pest Management which will low the remaining 50% of the 2023 funds to be used in 2024 to complete this project. Based on results from 2024, a decision will be made as to how and whether to conduct work in the 2025 field season.

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 grass controls.

Objective 1. Screen new herbicides for control of grass weeds in raspberry.
Objective 2. Screen existing herbicides for control of grass weeds in raspberry.

Procedures:

This project is anticipated to take two years to evaluate herbicide efficacy. If new active ingredients can be identified after two years, the IR-4 Project would be requested to register the products on raspberry.

This project would consist of a contact burndown herbicide trial and would involve registered and unregistered herbicides 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. We would do the trial in two locations. The trials 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.

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. We hope to identify if any existing registrations can be used more effectively for grass weed control. We also will determine if unregistered herbicides can increase grower ability to control grassy weeds. If unregistered products are identified, their registrations will be sought. This information will be communicated through print and digital outreach to growers as well as presentations at berry workshops such as the Skagit County Blueberry Workshop, CHS Grower Meeting, and the Washington Small Fruit Conference.

Budget:

	2024	2025
Salaries[1/]	$	$6,659
Time-Slip	$	$
Operations (goods & services)	$	$ 398
Travel[2/]	$ 719	$ 719
Meetings	$	$
Other	$5,529	$2,674
Equipment[3/]	$	$
Benefits[4/]	$	$2,045
Total	**$ 6,248**	**$12,495**

Budget Justification The funding for 2024 is for Dr. Tom Walters to make the applications, take ratings and travel to and from the research sites.

PHYSIOLOGY

WRRC Final 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
- Cooperator: Riley Spears @ Rader Farms

Reporting Period: 2024

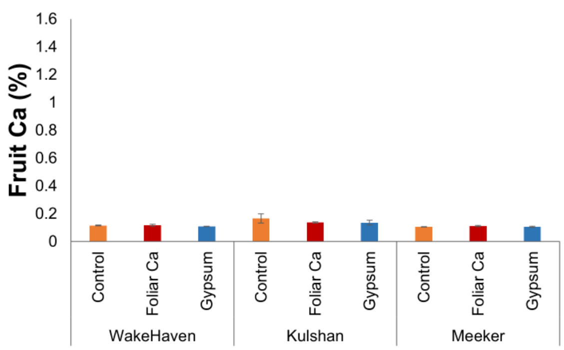
Accomplishments:

- *What are the main accomplishments of the project and their significance in terms of the problem solved or enhancements to the industry?* The objectives of this project were: 1) Determine timing of calcium accumulation across different stages and periods of fruit development in floricane raspberry; 2) Evaluate methods to increase calcium concentrations in raspberry leaves and fruits and assess the impacts on yield and fruit quality; and 3) Disseminate findings. We demonstrated when calcium accumulation begins and peaks within the fruits of commercially relevant cultivars of red raspberry. We also evaluated the potential of different fertilizer methods to increase calcium in the fruit and improve production or fruit quality through statistically robust field experiments. Information dissemination is underway and will guide informed fertilizer practices for the industry.
- *What has been contributed to science and/or the industry?* This project established when calcium accumulation begins and peaks within the floral and fruiting tissues of commercially relevant cultivars of red raspberry. Furthermore, two years of calcium fertilizer trials in commercial fields of 'Meeker', 'Kulshan', and 'WakeHaven' revealed that standard calcium fertilizer practices had no effect on yield, fruit quality, or calcium concentrations within the leaves or fruits. We consistently observed the receptacle accumulated over ten times more calcium than the druplets, signifying there is a physiological barrier limiting calcium movement from the receptacle into the fruit. Therefore, fertilizer programs targeting increasing calcium concentrations in fruits will have little to no effect on yield or fruit quality, provided leaf tissue nutrient sufficiency standards are within the recommended range for raspberry. Growers can consequently forego additional calcium fertilizers, particularly foliar fertilizers applied during flowering and fruit development, given they appear to be ineffective at elevating fruit calcium levels and have no obvious effect on yield or fruit quality.

Results:

1) *Determine timing of calcium accumulation across different stages and periods of fruit development in floricane raspberry*. The peak period of calcium uptake for 'Meeker', 'WakeField', and 'WakeHaven' raspberry was between stage S4 (immature green fruit) and S6 (white fruit).
2) *Evaluate methods to increase calcium concentrations in raspberry leaves and fruits and assess the impacts on yield and fruit quality***.** Field trials were conducted in 2023 and

2024 using ‘Meeker’, ‘WakeHaven’, and ‘Kulshan’ raspberry. Only one year of data were collected for the ‘WakeHaven’ and ‘Kulshan’ fields due to field turnover. Each field was set up as a randomized complete block design, with individual treatment plots spanning 56 ft (i.e., two post lengths) and replicated four times (i.e., 12 plots per field). Three treatments were applied per field, including a soil-applied calcium fertilizer applied prior to budbreak, a foliar calcium fertilizer applied during the peak period of calcium uptake as determined in Objective 1, and an untreated control with no calcium fertilizer (*treatment application information available upon request*). Plots were machine-harvested in collaboration with the grower cooperator and fruit quality was measured weekly. No statistically significant treatment effects were detected across the study for yield, fruit quality (including fruit firmness), soil calcium levels, or calcium concentrations within primocane leaves and raspberry fruits. Interestingly, in ripe fruit, the concentration of calcium in the receptacles was more than ten times higher than in the druplets of each cultivar (Figure 1). Furthermore, it differed by treatment in ‘WakeHaven’; in this case, receptacles collected from plots treated with foliar calcium contained the highest concentration of calcium, while those collected from the untreated control had the lowest. Thus, there appears to be a physiological barrier limiting calcium movement from the receptacle into the druplets that fertilizers applied at standard-label rates cannot overcome. These findings are highly suggestive that fertilizer programs targeting increasing calcium concentrations in fruits will have negligible to no impact on yield or fruit quality if the plants are within sufficiency standards.



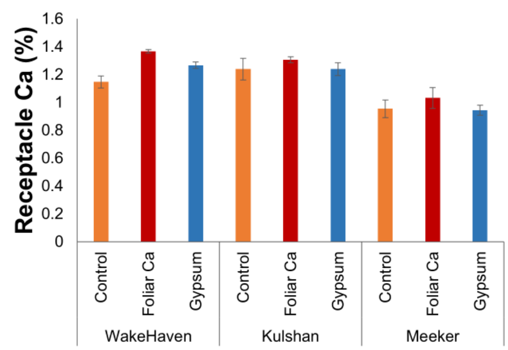


Figure 1. Fruit (left) and receptacle (right) calcium concentrations in ‘WakeHaven’, ‘Kulshan’, and ‘Meeker’ fruits collected in 2023 and 2024.

3) *Disseminate findings.* Findings were shared annually at the Lynden Ag Show/Small Fruit Conference in 2022, 2023, and 2024. Results will also be shared as a 2025 *Whatcom Ag Monthly* newsletter and a trade journal article.

Publications:

- Dias Da Silva, A., S. Orr, M. Kraft, M. Hardigan, B. Maupin, R. Pio, D.R. Bryla, and L.W. DeVetter. 2024. Calcium accumulation in developing fruits of raspberry and blackberry. Acta Hortic. 1388, 339-346. https://doi.org/10.17660/ActaHortic.2024.1388.49
- Silva, A.D., D. Bryla, and L.W. DeVetter. 2023. Pump it up! Timing of calcium uptake in raspberry fruits. WSU Whatcom Ag. Monthly. 12(1). https://extension.wsu.edu/wam/pump-it-up-timing-of-calcium-uptake-in-raspberry-fruits/

Washington Red Raspberry Commission Progress Report

Project No: 146041

Title: Determining leaf nutrient sufficiency standards for red raspberry in Washington

Personnel:

- PI: Lisa DeVetter, Associate Professor of Horticulture at WSU, Mount Vernon, WA
- Co-PI: Dave Bryla, Research Horticulturist at USDA-ARS, Corvallis, OR

Reporting Period: 2024

Accomplishments:

- *What are the main accomplishments of the project and their significance in terms of the problem solved or enhancements to the industry?* The objectives of this project were: 1) Determine leaf macro- and micro-nutrient sufficiency standards for traditional and new floricane-fruiting raspberry cultivars grown in northwest Washington and 2) Disseminate findings to stakeholders and develop a new raspberry nutrient management guide for the region. To accomplish the first objective, newly expanded primocane leaf tissue samples were collected every two weeks from mid-June through mid-September 2024. Samples were collected from productive commercial fields of 'Meeker', 'WakeHaven', 'WakeField', and 'Kulshan' within the Lynden area and included three fields per cultivar (n=12 fields total). Leaf samples were sent to Brookside Labs and analyzed for macro- and micronutrients. Data analysis was used to identify the most stable period(s) for leaf sampling and the normal range for each nutrient. Fall soil samples were also collected and sent to Brookside labs with results pending. Preliminary results for this two-year-long project were shared at the 2024 Lynden Ag Show as planned in the second objective.
- *What has been contributed to science and/or the industry*? Current sufficiency standards are outdated and have not been evaluated for new, machine-harvestable cultivars being widely adopted by the processed raspberry industry in northwest Washington. Moreover, current sufficiency standards originated from data collected in Oregon (Hart et al., 2006; Strik and Bryla, 2015) or, in the case of several nutrients, in northeastern United States (Bushway et al., 2008). Therefore, results from this project will provide cultivar-specific, regionally relevant standards for the northwest Washington raspberry industry.

Results: Tissue nutrients from 2024 have been analyzed and are presented in Table 1. Preliminary results indicate that the period of nutrient stability extends later into August and thresholds for nutrients, such as leaf nitrogen, should be higher than what is currently published in the latest nutrient management guidelines for raspberry (Davis et al., 2024).

Publications:

One extension publication has been co-authored by the collaborating scientists (see below). This guideline will be updated, and new guidelines will be published as a WSU Extension publication at the end of this project.

Davis, A., S. Lukas, B. Strik, A. Moore, L.W. DeVetter, D. Bryla, and E. Dixon. 2024. Nutrient management of raspberries and blackberries in Oregon and Washington. PNW Extension Publication. Pp. 35. PNW 780. *Available online for free*.

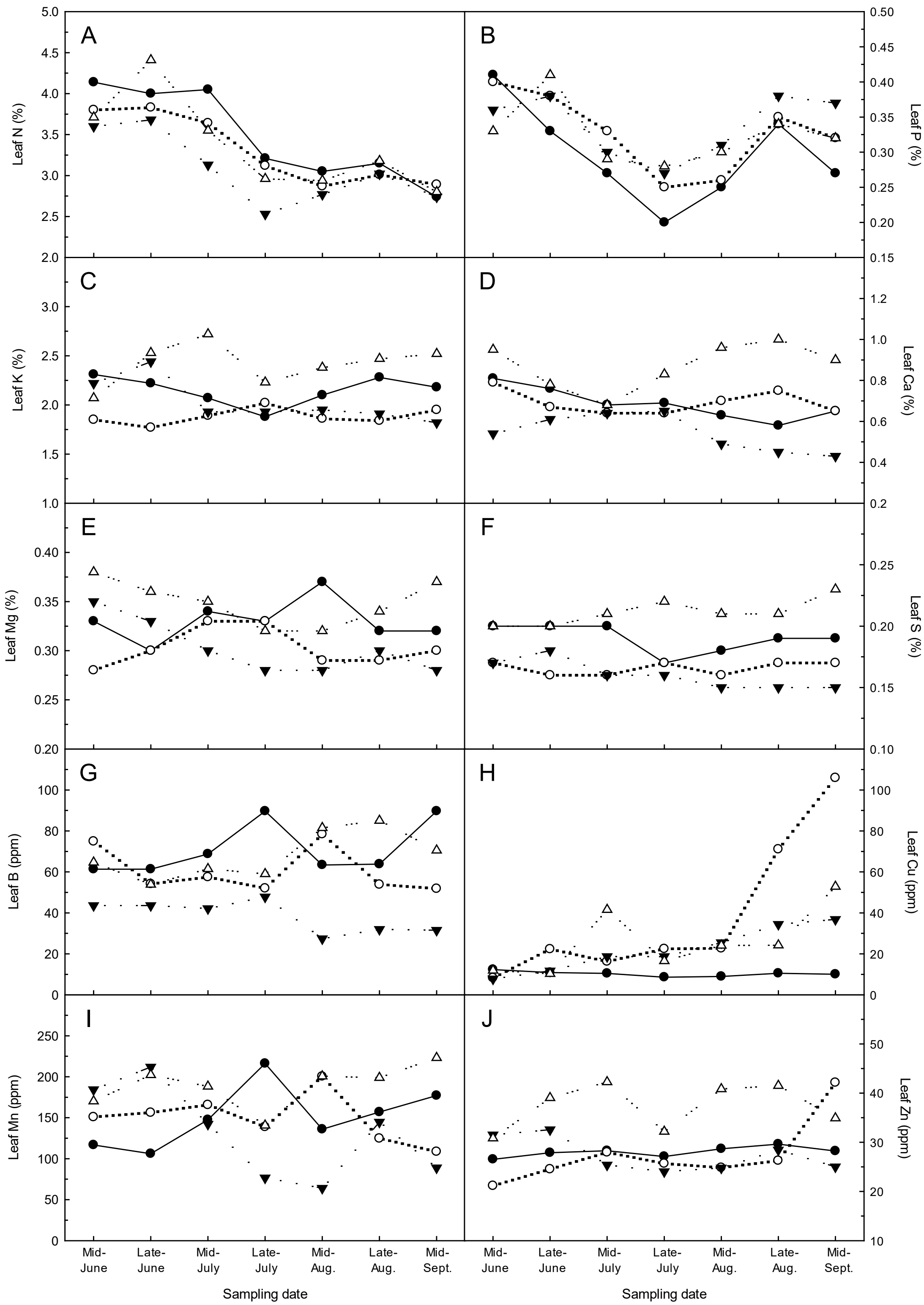


Fig 1. Concentration of macro- and micro-nutrients in newly expanded primocane leaves of ‘Meeker’ (●), ‘WakeHaven’ (○), ‘WakeField’ (▼), and ‘Kulshan’ (△) raspberry. Approximately 200 leaves were sampled every two weeks from mid-June to mid-September 2024 in three commercial fields of each cultivar within the Lynden area.

2025 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

Project Proposal: 146041 **Proposed Duration:** 2 years

Project Title: Determining leaf nutrient sufficiency standards for red raspberry in Washington

PI: Lisa DeVetter
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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

Year Initiated 2024 **Current Year** 2025 **Terminating Year** 2025

Total Project Request: $36,176 **Year 1** $16,748 **Year 2** $19,428

Other funding sources: None

Description:
Leaf tissue nutrient standards are often used to inform fertilizer programs, but the current guidelines for red raspberry are outdated and based on research conducted in Oregon and northeastern United States. There is an urgent need to update these standards for the Washington red raspberry industry so that they accurately reflect the new cultivars and unique growing conditions for the region. The primary objective of this proposal is to determine leaf macro- and micro-nutrient sufficiency standards for traditional and new floricane-fruiting raspberry cultivars grown in northwest Washington. Accomplishing this goal will address this knowledge gap and provide northwest Washington raspberry growers with updated tissue sufficiency standards for their specific production systems.

Justification and Background:
Leaf nutrient sufficiency standards are useful tools that many raspberry growers and crop consultants use in conjunction with leaf sampling and tissue nutrient assessments to guide their nutrient management programs. However, sufficiency standards are outdated and have not been evaluated for new, machine-harvestable raspberry cultivars that are currently being grown in northwest Washington, including cultivars such as 'WakeField', WakeHaven', and 'Kulshan'. These cultivars exhibit much greater vigor and yield potential than more traditional cultivars, such as 'Meeker', that were used to develop the original standards. Furthermore, published sufficiency standards originated from data collected in Oregon (Davis et al., 2024; Hart et al., 2006; Strik and Bryla, 2015) or, in the case of several nutrients, in northeastern United States (Bushway et al., 2008). Growing conditions in these regions are very different than those in Washington in terms of climate, soils, cultivar diversity, and overall productivity, which calls into question the applicability of using the current leaf tissue nutrient standards for Washington's raspberry production. Recent work in northern highbush blueberry demonstrated that patterns of

nutrient uptake and accumulation vary across the Pacific Northwest and led to the creation of specific standards for blueberries produced in western Oregon, western Washington, and eastern Washington (Lukas et al., 2022). It is very likely that leaf nutrient sufficiency standards are likewise different across regions for raspberries and preliminary findings from our 2024 project funded by the WRRC provides support of this hypothesis (*see provided progress report*). This project seeks to develop leaf nutrient sufficiency standards that are specifically for raspberry cultivars produced in northwest Washington.

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:

- Determine leaf macro- and micro-nutrient sufficiency standards for traditional and new floricane-fruiting raspberry cultivars grown in northwest Washington.
- Disseminate findings to stakeholders and develop a new raspberry nutrient management guide for the region.

Procedures:
Leaf nutrient sufficiency standards will be determined following procedures used previously for blueberry (Lukas et al., 2022; Strik and Vance, 2015) and implemented successfully in 2024 for raspberry. Recent fully expanded primocane leaves will be sampled every two weeks from mid-June through the end of September for two years (2024 and 2025). Samples will be collected from mature and productive fields of 'Meeker', 'WakeField', 'WakeHaven', and 'Kulshan' raspberry located in northwest Washington. We will sample three fields per cultivar, amounting to 12 fields in total. Within each field, 50 leaves will be collected from both sides of 330-ft-long transects (i.e., rows), with four transects per field (n=200 leaves/field for each sampling event). Immediately after samples are collected on each date, the leaves will be dried, ground, and analyzed for macro- and micronutrients by Brookside Laboratories (New Bremen, OH). Leaf N will be analyzed using a combustion analyzer, while other nutrients, including P, K, Ca, Mg, S, B, Cu, Fe, Mn, and Zn, will be analyzed using an inductively coupled plasma (ICP) optical emission spectrometer. Soil samples will also be collected in the fall and analyzed for pH, EC, organic matter content, cation- and anion-exchange capacity, and nutrients by Brookside Laboratories. We propose to collect data for two years to minimize variation experienced across years. Resulting data will be examined for seasonal changes in leaf nutrient concentrations in order identify 1) the most stable period(s) for leaf sampling and 2) the normal range for each nutrient in productive fields. We will also determine whether there are any positive or negative relationships between nutrients in the soil and the leaves. Interpretation of these data will provide guidance on the best time(s) to sample leaves for nutrient analysis, as well as optimal leaf and soil sufficiency ranges for 'Meeker' and the newer cultivars for the northwest Washington raspberry industry.

Anticipated Benefits and Information Transfer:
Results from this project will provide leaf nutrient sufficiency standards for the unique conditions and raspberry cultivars of northwest Washington. To our knowledge, this is the first time that sufficiency standards have been developed for traditional and new cultivars of

floricane-fruiting raspberry grown in northwest Washington. Information will be shared annually at the Washington Small Fruit Conference, and an extension document will be produced that outlines the sufficiency standards developed from this research.

References:

Bushway, L., Pritts, M., and Handley, D. (eds.). 2008. Raspberry & blackberry production guide for the Northeast, Midwest, and Eastern Canada. Natural Resource, Agriculture, and Engineering Service Cooperative Extension. NRAES-35.

Davis, A., S. Lukas, B. Strik, A. Moore, L.W. DeVetter, D. Bryla, and E. Dixon. 2024. Nutrient management of raspberries and blackberries in Oregon and Washington. Pacific Northwest Extension Publication. Pp. 35. PNW 780. https://extension.oregonstate.edu/catalog/pub/pnw-780-nutrient-management-raspberries-blackberries-oregon-washington.

Hart, J.M., Strik, B., and Rempel, H. 2006. Caneberries nutrient management guide. Oregon State University. EM 8903. https://catalog.extension.oregonstate.edu/em8903.

Lukas, S., Singh, S., DeVetter, L.W. and Davenport, J.R. 2022. Leaf tissue macronutrient standards for northern highbush blueberry grown in contrasting environments. Plants 11(23): 3376 https://doi.org/10.3390/plants11233376.

Strik, B.C. and Bryla, D.R. 2015. Uptake and partitioning of nutrients in blackberry and raspberry and evaluating plant nutrient status for accurate assessment of fertilizer requirements. HortTechnology 25(4):452-459. https://doi.org/10.21273/HORTTECH.25.4.452.

Strik, B.C. and Vance, A.J. 2015. Seasonal variation in leaf nutrient concentration of northern highbush blueberry cultivars grown in conventional and organic production systems. HortScience 50(10):1453-1466 https://doi.org/10.21273/HORTSCI.50.10.1453.

Budget:

	2024	**2025**
Salaries[1/]	$9,787	$10,511
Time-Slip	$	$
Operations (goods & services) [2/]	$1,150	$2,650
Travel3[/]	$943	$965
Meetings	$	$
Other	$	$
Equipment	$	$
Benefits[4/]	$4,868	$5,302
Total	**$16,748**	**$19,428**

Budget Justification

[1/]Salary for technicians in the Small Fruit Horticulture program (Emma Rogers and Brian Maupin) at 1.2 months and 100% FTE each in Years 1 and 2.

[2/]Fees for leaf and soil analysis ($1,000/year), shipping samples ($150/year), and manuscript fees for publication ($1,500 in Year 2).

[3/]Roundtrip travel from WSU NWREC in Mount Vernon to raspberry fields in Lynden, Washington. Estimate derived from 16 sampling dates/year (90 miles round trip x $0.67/mi x 16 trips/year).

[4/]Benefits for Small Fruit Horticulture program technicians, Emma Rogers (51.5%) and Brian Maupin (49.6%).

*Approved by Kara Harder, Dec. 9, 2024.

PATHOLOGY VIROLOGY

A Report to the Washington State Red Raspberry Commission

Title: Control of Cane Blight in Raspberry

Year Initiated: 2024 **Current Year**: 2024 **Terminating Year**: 2026

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.

Justification and Background: Cane blight, *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 the 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 several of the other newer varieties such as Cheminus 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 40% of Washington's raspberry acreage and up to 50% of the state's production. There are non-chemical control options that can reduce infections including pruning out infected canes, avoiding excess nitrogen, adjusting harvester catch 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 worse problem. The primary means of controlling the disease is expected to be fungicides. No other research is being done to address this issue. Currently, the two products recommended for control of cane blight are Tanos (famoxadone (Group 11) and cymoxanil (Group 27)) and QuiltXcel (propiconazole (Group 3) and azoxystrobin (Group 11)), butcane blight is not on either label. Tanos requires rotation with fungicides containing different modes of action. The only products registered on cane berries that have cane blight on the label are copper and lime sulfur products (14 total products between the two types of products.) 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. 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 Elevate (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. Dr. Jones 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. This is the only research being conducted against this disease on raspberries in the United States.

To establish efficacy against cane blight, it requires a minimum of two years of research. A key determinate of efficacy is how much cane blight is on the floricanes (second year's growth which produces the fruit). Applications have to be made on the primocanes (first year's growth) and also the subsequent year's growth (floricanes). We have one year of good data from this research project, which was supported by the WSCPR. We expect this year to likely be the end of this project. We have identified at least two products that appear to have efficacy against cane blight.

Materials and Methods

This is year one of a 3-year trial. A raspberry cane blight trial was conducted in April 2024 by Agricultural Development Group, Inc. about 6 miles south of Lynden, WA to evaluate the effect of different fungicides on raspberry cane blight. The experimental design was a RCB with 4 replications with the plot size of 10 ft x 30 ft. Applications were make on April 18 (within 2 days of first pruning), July 2 (2 days before first harvest), July 12, July 25, and August 10, 2024. The applications for this trial were made by an over the row sprayer to apply treatment spray at 85 gallons/acre. 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 July 25. The number of infected primocanes out of 50 primocanes will be evaluated around early December. Then the % incidence for floricane and primocane infections was/will be calculated using infected canes divided by the 50 x 100%.

Results and Discussion

The result of infected floricanes incidence showed that although not statistically different, Abound, Cabrio, Pristine, Quilt Xcel, Captan 80 WDG, Miravis Prime, and Luna Tranquility had 3%, 3%, 1%, 0.5%, 2%, 2.5%, and 2% numerically less incidence compared to untreated check, respectively. We will update the infected primocane result once we finish evaluation. We have one evaluation yet to make later this year. The true evaluation of this project will be following the second year of applications when the primocanes treated this year are treated as floricanes. So, two years of applications are required to understand comparative efficacy. We expect this to be a three year project which means we will have two years of efficacy data on these treatments.

Table 1. Treatment list and application timings.

Trt No.	Type	Treatment Name	Form Type	Rate	Rate Unit	Appl Code
1	CHK	Untreated check				
2	FUNG	Abound	L	10.75	fl oz/a	ABCDE
3	FUNG	Cabrio	SG	14	oz/a	ABCDE
4	FUNG	Pristine	SG	20.75	oz/a	ABCDE
5	FUNG	Quilt Xcel	L	17.5	fl oz/a	ABCDE
6	FUNG	Captan 80 WDG	SG	2.5	lb/a	ABCDE
7	FUNG	Miravis Prime	L	11.8	fl oz/a	ABCDE
8	FUNG	Luna Tranquility	L	21	fl oz/a	ABCDE

Table 2. ANOVA table for floricane infection incidence.

Rating Date					Jul-25-2024
Rating Type					Floricane infected
Rating Unit					%
Rating Min/Max/Interval					0, 100, -
Number of Subsamples					1
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	1
1	Untreated check				19.0a
2	Abound	10.75	fl oz/a	ABCDEFGHI	16.0a
3	Cabrio	14	oz/a	ABCDEFGHI	16.0a
4	Pristine	20.75	oz/a	ABCDEFGHI	18.0a
5	Quilt Xcel	17.5	fl oz/a	ABCDEFGHI	18.5a
6	Captan 80 WDG	2.5	lb/a	ABCDEFGHI	17.0a
7	Miravis Prime	11.8	fl oz/a	ABCDEFGHI	16.5a
8	Luna Tranquility	21	fl oz/a	ABCDEFGHI	17.0a
LSD P=.05					7.17
Standard Deviation					4.87
CV					28.26
Grand Mean					17.25
Levene's F^					2.479*
Levene's Prob(F)					0.046*
Rank X2					.
P(Rank X2)					.
Shapiro-Wilk^					0.9768
P(Shapiro-Wilk)^					0.7034
Skewness^					0.3293
P(Skewness)^					0.4534
Kurtosis^					0.6263
P(Kurtosis)^					0.4651
Replicate F					0.323
Replicate Prob(F)					0.8089
Treatment F					0.216
Treatment Prob(F)					0.9774

Rating Unit
%, 0, 100, = percent

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.
^Calculated from residual.

Figure 1. Effect of different fungicides on raspberry cane blight-on floricanes.

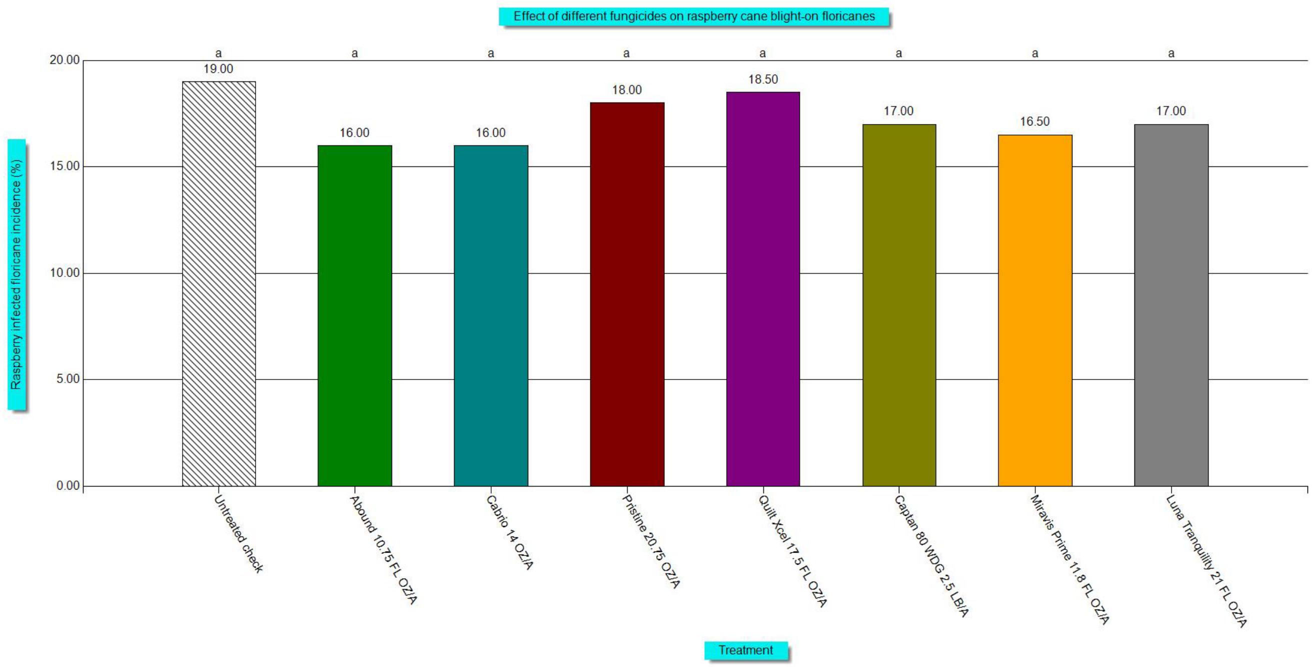

Photo 1. Foliar application using over the row sprayer on April 18 (left) and July 2 (right), 2024.

Photo 2. Raspberry on July 2.

(Assigned by WCIPM) **Project #** ___________________

PROJECT TITLE: Cane Blight on Raspberry Revisited - Year 2

APPLICANT:	**PI/RESEARCHER:**
User Group: Washington Red Raspberry Commission	Name: Alan Schreiber
Contact: Henry Bierlink	Institution: Agriculture Development Group, Inc.
Phone: 360 815 9117	Phone: 509 266 4348
Email: Henry@red-raspberry.org	Email: aschreib@centurytel.net

DETAILS:

Treatment Method *(Select one):* ☒ Pesticides ☐ Alternative to Pesticides

Crop: Raspberry Pest: Cane Blight

Registration: 50% Non-Registration: 50%

CATEGORIES:

Good Laboratories Practices Research *(Select all that apply):* ☐ GLP ☒ Not GLP

Impact Categories *(Select all that apply)*:

☐ A1 ☐ A2 ☐ A3 ☐ A4 ☐ A5 ☐ B1 ☐ B2 ☐ B3 ☐ B4 ☐ C1 ☒ C2 ☒ C3 ☐ C4

Project Type *(Select all that apply)*:

☒ Efficacy Trial ☐ Residue Study ☐ Pesticide Resistance Study

☒ Phytotoxicity Study ☐ Integrated Pest Mgmt. ☐ Other:

FUNDING*:

Start Date: 2/1/2025 End Date: 12/1/2025

WCIPM Request: $ 18,000

Fund Contributions Cash: $ 15,000 *From* Washington Red Raspberry Commission

Fund Contributions In-kind: $ 6,000 *From* Two raspberry growers

Total Project Cost: $ $39,000

PROJECT SUMMARY:

Cane blight is a terrible disease that is severe problem of half of the raspberries grown in the state. Most of the new raspberry varieties grown in Washington state are considered highly susceptible to this disease. The initial work on this effort had mixed results and were disappointing. New research out of the southeastern United States on caneberries indicates there is value in a new approach using previously untried modes of action, timings and number of application. This proposal is for year 2 of what is expected to be a three year project.

To the best of my knowledge, my signature certifies that the information in this application is true and correct.

Henry Bierlink Executive Director

User Group Applicant Name (Print) *User Group Applicant's Title*

November 8, 2024

Group Applicant Signature *Date*

Problem Description

Cane blight, *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 following 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 the 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.

Pacific Berries cultivars (WakeField, WakeHaven), Driscoll's cultivars and several of the other newer varieties such as 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. Highly susceptible varieties make up more than 50 % of Washinton's raspberry acreage. 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.

Schreiber conducted research on this problem in 2020, 2021 and 2022 and concluded the Luna Tranquility and Miravas Prime were the most effective products for reducing cane blight symptoms, however the level of efficacy was disappointing. Additionally, it was determined that Velum Prime, same active ingredient as in Luna Tranquility, was applied for cane blight was also very effective at controlling root lesion nematode an important pest of raspberry. This project ended in 2022.

However, recent research out of the southwestern U.S. on cane blight indicates that the approach Schreiber took, use of *Botrytis* fungicide and Tanos applied during harvest, was probably not the best approach. The logic was applying products during harvest when entry points for the disease created by harvesters occurred. The new recommendations are to start applications much earlier, apply more often and use some different fungicides. The new recommendations have applications start at delayed dormant (not at prebloom as before), then apply at 6 inch shoot length and again before preboom, early bloom, full bloom, petal fall, cover sprays through harvest. This program is probably ten applications as opposed the previous six applications. The products recommended by southeastern caneberry pathologist are Abound, Cabrios, Pristine and Quilt Xcel. Captan was described as having fair efficacy. Since this product is commonly used in blueberries, it should be included.

Lisa Jones, a Ph.D. plant pathologist with Pacific Berries, has carried out field and laboratory investigations on cane blight including the first identification of the disease on WakeField raspberry. Enfield Farms and Dr. Jones have agreed to be cooperators on the project.

To establish efficacy against cane blight, it requires a minimum of two years of research. A key determinate of efficacy is how much cane blight is on the floricanes (second year growth which produces the fruit). Applications have to be made on the primocanes (first year growth) and also the subsequent years growth (floricanes). All applications were made in 2024 but a second year's set of applications are required to collect efficacy data on the floricanes.

Value of the Industry. The Washington raspberry industry is comprised of 9,200 acres and is valued at approximately $81 million at the farmgate.

Losses due to cane blight. No data exists on this, but the industry is planted to about 40% of susceptible varieties and the number of acres is increasing. Growers are making multiple applications of fungicides and many of the applications may not be the correct active ingredients. There is no accurate estimate of yield loss from this relatively new disease but it is significant enough to make cane blight a high priority for the WRRC research efforts.

Acres Impacted. About 40% of Washington raspberries are impacted.

Aggregate impact to the industry. The aggregate impact on the industry is not known; control costs are roughly $500,000, not including yield losses from cane blight.

Effect of the problem on the industry. Due to its higher yield and quality, growers are planting new varieties of raspberries which is a significant investment and this new disease is compromising the value proposition of the new varieties due to increase control costs and reduced yields.

Effect of the problem on consumers, society, environment, non-target species or human health. Uncontrolled cane blight is reducing the amount of raspberries available for consumers.

Description of alternative control measures and why they are not effective or additional information on the specific need. Non-chemical control measures can reduce inoculum but is not a viable means for controlling the disease. Use of non chemical control measures have to be used in conjunction with commercial fungicides.

Funding Categories. Category C - Significance to Local or Regional Economy

Sub-Category #2 - Development of an integrated pest management tactic
Sub-Category #3 - Registration of an additional pest control tactic

Project Description

We propose to conduct efficacy trials in two susceptible raspberry varieties, most likely WakeHaven, WakeField or Chemainus. Products to be included in the trial are but are not limited to Abound, Cabrio, Pristine, Quilt Scel, Captan, Miravis Prime and Luna Tranquility. The trials will be in Whatcom County. The trials will have four replications and will have a RCB design. A minimum trial length is two years because applications have to be made to the primocanes in year one which turn into floricanes in year two. The same applications need to be made to the same plots both years. The final results will be reduction of symptoms on the floricanes in year two. We estimate that 10 or more applications will be required to control this pest.

Who certified this budget for accuracy?
Name: Cheryl McClaren Title: Bookkeeper
Email: cheryll@centurytel.net

TOTAL PROJECTED [ESTIMATED] EXPENDITURES:

TABLE 1	WCIPM Request	FUND CONTRIBUTIONS			TOTAL
		Cash-WRRC	In-kind	In-kind Time	
Salaries[1]	$10,000	$3000	$	$	$13,000
Benefits	$ 3,500	$1,050	$	$	$ 4,550
Temp/Hourly Workers	$ 1,000	$	$	$	$ 1,000
Travel[2]	$ 2,000	$ 950	$	$	$ 2,950
Field Location	$	$	$6,000	$	$ 6,000
Trial/Project Supplies	$1,500	$	$	$	$ 1,500
Walters Ag Research[4]	$	10,000	$	$	$10,000
TOTAL*	18,000	15,000	$ 6,000	$	$39,000

[1] Agricultural Researcher
[2] Travel to and from Fidalgo Island to plots in Whatcom County
4 contract with Walters Ag Research to make applications and take counts and samples.
The value placed on the two research locations is $3,000 each.

PROJECTED [ESTIMATED] EXPENDITURES BY QUARTER:

TABLE 2	*2024 Q1 (Jan-Mar)*	*2024 Q2 (Apr-Jun)*	*2024 Q3 (Jul-Sept)*	*2024 Q4 (Oct-Dec)*	*2025 Q1 (Jan-Mar)*	*2025 Q2 (Apr-Jun)*
WCIPM Funds	$1,000	$8,000	$8,000	$1,000	$	$
Fund Contributions	$1,000	$7,000	$7,000	$1,000	$	$

TOTAL*	$2,000	$8,500	$8,500	$2,000	$	$

Has this project been funded previously by WCIPM? ☒ YES ☐ NO

Cabrio, Pristine, Quilt Xcel, Captan 80 WDG, Miravis Prime and Luna Tranquility were applied to commercial raspberries. Data were collected but as expected there was minimal efficacy as the disease was already established prior to start of the trial. The applications made in 2024 to the primocanes is expected to set the stage for the application in the 2025 season for a late summer evaluation on floricanes which will have been protected for two years.

Washington Red Raspberry Commission
Final Report for Project from 2022-2024

Project No: 22PN025
Project Title: Characterization of *Botrytis* spp. on red raspberries in Northwestern Washington
Personnel: Virginia Stockwell and Jeff DeLong, USDA-ARS Horticultural Crops Disease and Pest Management Research Unit; Chakradhar Mattupalli, Department of Plant Pathology, Washington State University
Reporting Period: February 2022 – December 2024

Background: Washington is the one of the leading producers of red raspberries in the U.S. with a production of 69 million pounds harvested from 8,900 acres to generate a revenue of $63 million (NASS, 2021). The fungus, *Botrytis* spp. is reported to cause serious pre- and postharvest losses on small fruits and on over 200 economically important crop hosts worldwide (14). The regional climate in northwestern Washington contributes to the disease pressure from *Botrytis* spp. that cause fruit rot and gray mold on red raspberries. Infection of raspberry flowers and berries by *Botrytis* can reduce yield and berry quality (2, 8, 10). Application of synthetic fungicide sprays are the primary management strategy for control of gray mold on raspberries and other small fruit crops. *Botrytis* is a "high risk" pathogen for the development of fungicide resistance owing to its genetic diversity, high fecundity (production of millions of spores rapidly), and ability to spread in fields (1, 5, 6, 12, 16).

Reduced sensitivity 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 (5, 15, 18, 19). The development of and increasing prevalence of fungicide tolerance in *Botrytis* has become a serious problem for effective disease control. An increasing number of isolates are tolerant to not only a single fungicide but also to multiple fungicides of different chemical classes (3, 11, 17). Fungicide resistance frequencies can differ between years, crop hosts, locations, and among different strains of *Botrytis* spp. (3, 10). Previous studies detected high levels of genetic variation for *Botrytis* isolates among fields and even on a single plant (4). While genetic variability of *Botrytis* isolates may influence the development of fungicide resistance it's more likely that environmental variation (locations, hosts, fungicide applications) are primary drivers for increasing fungicide tolerance. Because different mutations in *Botrytis* spp. can affect fungicide tolerance profiles, it is critical to assess these developing mutations conferring fungicide tolerance and their stability to develop better disease management strategies.

This proposal addresses the impact category 'C' and sub-Category #2, *which is resistance management and only one alternative exists, and pest has a history of developing resistance*.

Accomplishments:

Assessed the relative sensitivity of *Botrytis* isolates to different fungicide chemistries that are routinely used in red raspberry production in the PNW. We sampled 12 conventionally managed red raspberry fields in Whatcom County at three sampling times (overwintering, bloom, and harvest) during the 2022 and 2023 growing seasons. Overall, we collected over 1,176 *Botrytis* isolates. We grew the isolates on culture media to produce spores (conidia) and selected one spore from each isolate to obtain 'mono-conidial' *Botrytis* isolates. A subset of 834 mono-conidial *B. cinerea* isolates were tested for fungicide resistance. We evaluated the ability of spores to germinate on media containing one of the following technical-grade fungicide: FRAC group 7 (boscalid or fluxapyroxad at 10 ppm; fluopyram or isofetamid at 5 ppm) and FRAC group 9 (cyprodinil or pyrimethanil at 4 ppm).

An enzyme important in fungal respiration and energy production, succinate dehydrogenase (SDH), is the target for FRAC 7 fungicides. There are four protein subunits (named A through D) of SDH (the genes are called *sdhA*, *sdhB, sdhC*, and *sdhD*) that interact and function together to generate energy for *Botrytis*. Binding of a FRAC 7 fungicide to important regions of the SDH subunits reduces/inhibits the function of this enzyme for energy production. Resistance of *Botrytis* to FRAC 7 fungicides is associated with genetic changes (mutations) in subunits *sdhB, sdhC*, and *sdhD* that reduce or prohibit binding of the fungicide to the SDH protein complex in *Botrytis*. Some mutations result in resistance to only one of the FRAC 7 fungicides, whereas other mutations result in resistance of *Botrytis* to several FRAC 7 fungicides. To characterize the mutations, present in the *Botrytis* isolates from red raspberry fields, we sequenced the genes *sdhB, sdhC*, and *sdhD* using primer pairs developed by Leroux et al (2010) for a subset of 28 isolates of *Botrytis* that were either sensitive to all of the tested FRAC 7 fungicides or had reduced sensitivity to one or more of the FRAC 7 fungicides.

Results:

In 2022, the relative frequencies of fungicide tolerance observed for the two FRAC 9 chemistries tested at each time point (overwintering, bloom and harvest, respectively) were: cyprodinil (0.06, 0.07, 0.09) and pyrimethanil (0.24, 0.28, 0.44). For the FRAC 7 materials, the fungicide tolerance frequencies for each time point for 2022 were: boscalid (0.37, 0.41, 0.50), fluopyram (0.67, 0.71, 0.80), fluxapyroxad (0.11, 0.11, 0.26), and isofetamid (0.09, 0.10, 0.25).

The fungicide tolerance frequencies for the two FRAC 9 chemistries tested at each time point (overwintering, bloom and harvest, respectively) for 2023 were cyprodinil (0.09, 0.14, 0.16) and pyrimethanil (0.44, 0.40, 0.55). For the FRAC 7 materials, the fungicide tolerance frequencies for each time point for 2023 were: boscalid (0.37, 0.41, 0.47), fluopyram (0.80, 0.82, 0.89), fluxapyroxad (0.27, 0.21, 0.25), and isofetamid (0.22, 0.23, 0.21). Of the 834 isolates, 0.01 were tolerant and 0.03 were sensitive to all six fungicides evaluated (Figure 1).

In general, our data indicates there is a trend of fungicide tolerance that is increasing between each sampling timepoint: overwinter (Mid- January), bloom (Mid-April) and harvest (Mid-July) for the 2022 and 2023 growing seasons. On a larger scale, the portion of the *Botrytis* isolates that are fungicide tolerant remained stable between samples collected near harvest of July 2022 and the samples of mid-January 2023 for all fungicides (with the exception of boscalid). Taking the smaller trend between timepoints and the larger trend across years, the data suggests there is a reservoir of fungicide tolerance maintained in the pathogen population that is increasing with respect to time.

Multi-fungicide tolerance was evaluated for each of the FRAC 7 fungicides using the same subset of 834 isolates. The relative frequencies for each time point (overwintering, bloom and harvest, respectively) for reduced tolerance to all four FRAC 7 chemistries (boscalid, fluopyram, fluxypyroxad, and isofetamid) were: 2022 (0.05, 0.10, 0.19) and for 2023 (0.14, 0.17, 0.17). While other multi-fungicide tolerance groups consisting of two or three different combinations of FRAC 7 chemistries was observed (Table 1), multi-fungicide tolerance to all four FRAC 7 fungicides evaluated remained the highest.

While evaluating *Botrytis* isolates for multi-fungicide tolerance to the four FRAC 7 fungicides, repeating patterns of tolerance were observed among the isolates. For example, isolates tolerant of isofetamid were often tolerant of boscalid, and similarly, isolates tolerant of fluopyram often were tolerant of fluxapyroxad. While these associations are not the rule, and there are multiple other phenotypic patterns associated with multi-fungicide tolerance within our dataset, we investigated the molecular basis for these phenotypic patterns by sequencing the succinate dehydrogenase subunits *sdhB, sdhC,* and *sdhD* of 28 *Botrytis* isolates to detect and characterize mutations present in the subunits of the SDH enzyme.

Analysis of *sdhB* sequences from *Botrytis* isolates (n=28) exhibiting different levels of sensitivity to any of four SDHI fungicides (boscalid, fluopyram, fluxypyroxad, and isofetamid) revealed four previously characterized mutations in 23 isolates: P225F (proline to phenylalanine), N230I (asparagine to isoleucine), H272R (histidine to arginine), and H272V (histidine to valine) at frequencies 0.43, 0.25, 0.11, and 0.04 respectively.

In the *sdhC* sequence analysis of the 28 *Botrytis* isolates, the mutation G37S (glycine to serine) was observed in 14/28 (50%) of the isolates, one of which also carried a P80H (proline to histidine) mutation. One isolate lacked the G37S and P80H mutation, but had had four unique simultaneous mutations G85A (glycine to alanine), I93V (isoleucine to valine), M158V (methionine to valine), and V168I (valine to isoleucine) in SDH subunit C. Novel *sdhC* mutations G37S and P80H are predicted to persist through positive selective pressure for pathogen fitness with respect to mycelial growth, conidiation, spore germination, sclerotium formation, stress tolerance, virulence and are associated with decreased sensitivity to SDHI fungicides (22, 23) and may contribute to the increasing trend in frequency to fungicide tolerance.

Novel *sdhD* mutations were revealed in all 28 Botrytis isolates S27P, F22S, S29R, R61K, and I129X at frequencies of 1.0, 0.14, 0.04, 0.04, and 0.04 respectively. None of these *sdhD* mutations are known to confer tolerance to SDHI fungicides. Mutations in the *sdhC* and *sdhD* genes in *B. cinerea*, although less prevalent than *sdhB*, also have been linked with resistance to SDHI fungicides (3, 22).

Our data suggests the existence of *Botrytis* isolates observed in conventionally managed red raspberry fields in Northwestern Washington that are tolerant to one or more of the FRAC 7 chemistries boscalid, fluopyram, fluxypyroxad, or isofetamid are due to the increased frequency of P225F, N230I and H272V mutant genotypes. Previous studies have revealed these *sdhB* mutations contribute to cross resistance of FRAC 7 fungicides (20, 21).

Figure 1. *Botrytis cinerea* fungicide tolerance over time. Data set consists for 834 mono-conidial *B. cinerea* isolates collected from 12 fields over three sample times during the 2022 to 2023 growing season

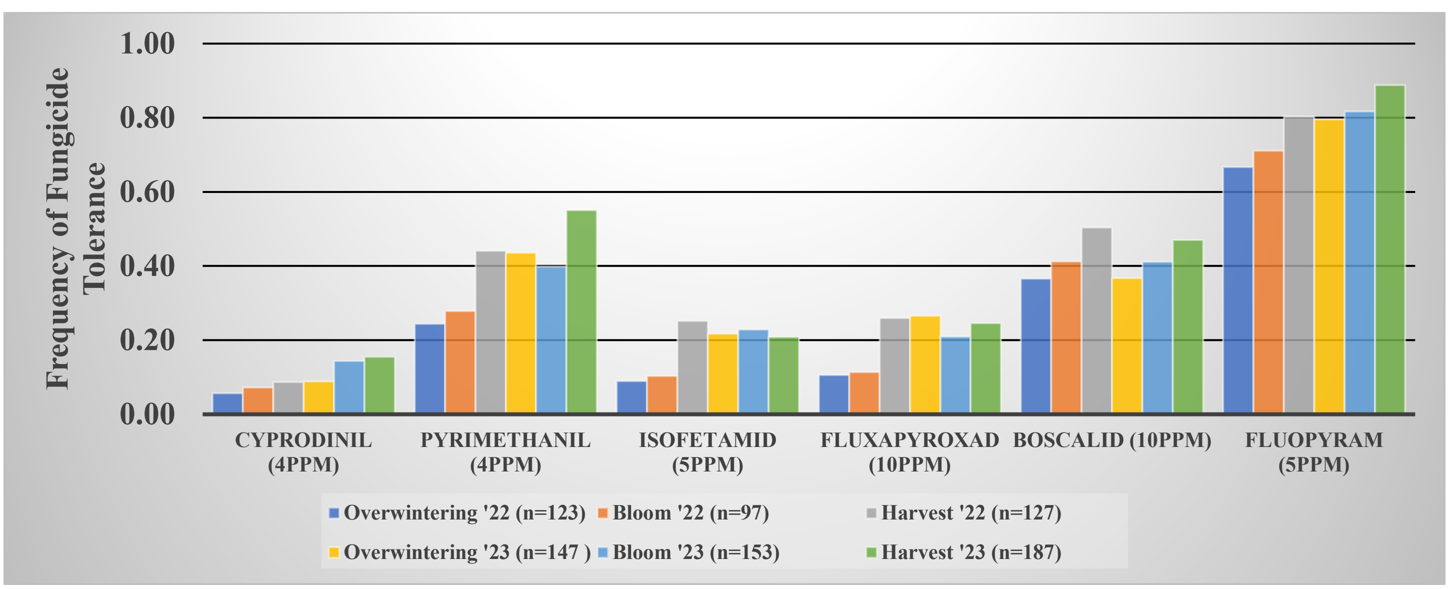

Table 1. *Botrytis cinerea* frequency of fungicide tolerance to multiple FRAC 7 chemistries. Data set consists of 834 mono-conidial *B. cinerea* isolates collected from 12 fields over three sample times during the 2022 to 2023 growing season

FRAC 7 Fungicide	Overwinter '22 (n=123)	Bloom '22 (n=97)	Harvest '22 (n=127)	Overwinter '23 (n=147)	Bloom '23 (n=153)	Harvest '23 (n=187)
Boscalid and Fluopyram	0.15	0.19	0.19	0.11	0.16	0.22
Fluopyram, and Fluxypyroxad	0.02	0.00	0.01	0.05	0.00	0.00
Fluopyram, Fluxypyroxad and Isofetamid	0.00	0.00	0.19	0.03	0.02	0.03
Boscalid, Fluopyram, and Fluxypyroxad,	0.03	0.01	0.03	0.03	0.01	0.04
Boscalid, Fluopyram, and Isofetamid	0.02	0.00	0.02	0.02	0.02	0.00
Boscalid, Fluopyram, Fluxypyroxad, and Isofetamid	0.05	0.10	0.19	0.14	0.17	0.17

References:

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(15) Plesken, C., et al. 2015. *Appl. Environ. Microbiol.* 81:7048–7056.
(16) Rupp, S., et al. 2017. *Front. Microbiol.* 7:2075.
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(18) Weber, R. W. S. 2011. *Plant Dis.* 95:1263–1269.
(19) Zhang, X., et al. 2016. *Front Microbiol*. 7:1482-149
(20) Leroux, P., et al. 2010. *Environ Microbiol,* 76:6615-6630
(21) Alzohairy, S., et al. 2023. *Phytopathology,* 113:998-1009
(22) Shao, W., et al. 2020. *Mol. Plant Microbe Interact,* 33:580-589
(23) Liu, S., et al. 2021. *Plant dis*., 105:628-635

Title: Extending the lifetime of plantings with novel post-plant nematicides
Personnel: Thomas Walters, Walters Ag Research; Inga Zasada, USDA-ARS HCRL
Reporting Period: 2024
Accomplishments:

- Evaluated fluopyram (Velum Prime) and fluazindolazine (Salibro, Reklemel) drip applications to control dagger nematode (*Xiphinema americanum, Xiphinema bakeri*) in three established raspberry plantings.
- Fluazindolazine reduced *Xiphinema* numbers by about half. This effect was significant in two of the three trials.
- Fluopyram was not effective on *Xiphinema* in any of the trials.

Results: Two fields with significant *Xiphinema* populations were identified in fall 2023. Pretreatment samples were collected from these June 2024. A third field was added August 2024; no pretreatment samples were collected at this location. Plots were laid out with four replicate plots/treatment and each plot 10 x 30 ft long. Application dates and rates are indicated in Table 1 below. Products were applied through drip line, applying approximately 0.25-0.5 inches of water to the beds.

Soil samples for nematode analysis were collected June (pretreatment), August 20, and September 27. They were processed in the Zasada lab at USDA-HCRL. In Trial 1, August Xiphinema numbers were significantly reduced by July Salibro and Velum+Salibro treatments, but not by Velum Prime alone (Figure 1).

Similarly, in Trial 2, September *Xiphinema* numbers were numerically lower in August Salibro and Velum+Salibro treatments, but this effect was not significant. However, when treatments were grouped by Salibro treatment, those plots treated with Salibro had significantly fewer *Xiphinema* than plots not treated with Salibro (Figure 2).

Salibro-treated plots had numerically fewer nematodes than plots not treated with Salibro in trial 3, but these differences were not statistically significant.

These three trials were consistent in that one or two treatments with Salibro at 61.5 fl oz/a in July or August reduced *Xiphinema* numbers by about 50%. Salibro does not yet have raspberry on the label, but this may change soon. Current cost for this rate of Salibro is approximately $240/acre.

Publications:

- Managing Dagger Nematodes in Raspberry. Oral presentation, Small Fruit Conference, Lynden WA, Dec 5
- Note in Small Fruit Update (planned, winter 2024-2025)

Table 1. Treatments, rates and application dates for 2024 nematicide trials.

Product and rate	Trial 1	Trial 2	Trial 3
Pretreatment samples?	Yes	Yes	No
Untreated Check	7/19	8/19	7/20
Salibro SC 61.5 fl oz/a	7/19	8/19	7/20
Salibro SC 61.5 fl oz/a			7/20, 8/20
Salibro SC 61.5 fl oz/a + Velum Prime, 6.84 fl oz/a	7/19	8/19	7/20, 8/20
Velum Prime, 6.84 fl oz/a	7/19	8/19	7/20
Velum Prime, 6.84 fl oz/a			7/20, 8/20

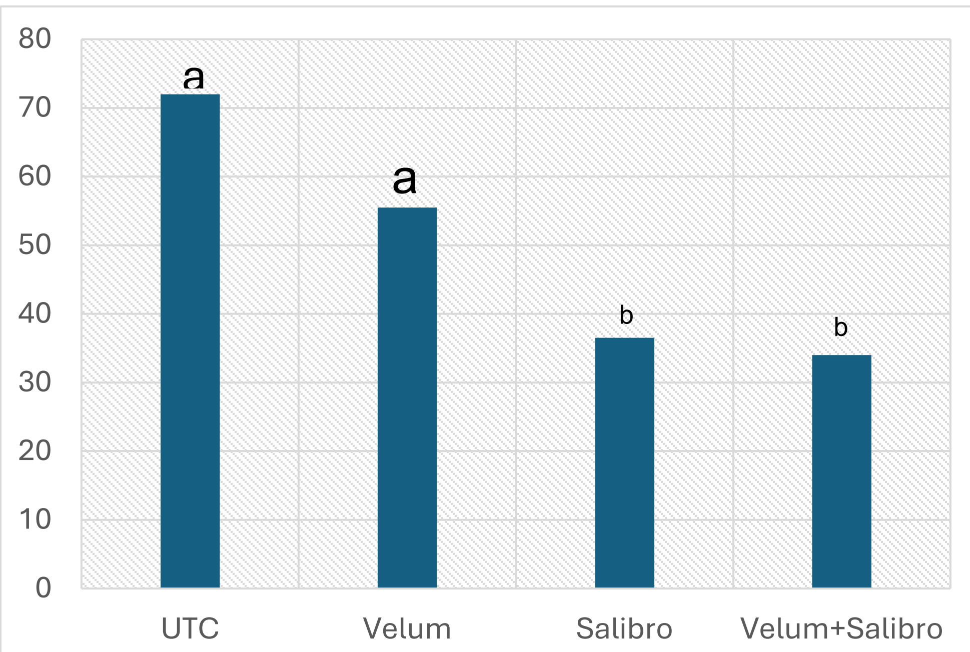

Figure 1. August *Xiphinema* readings, Trial 1

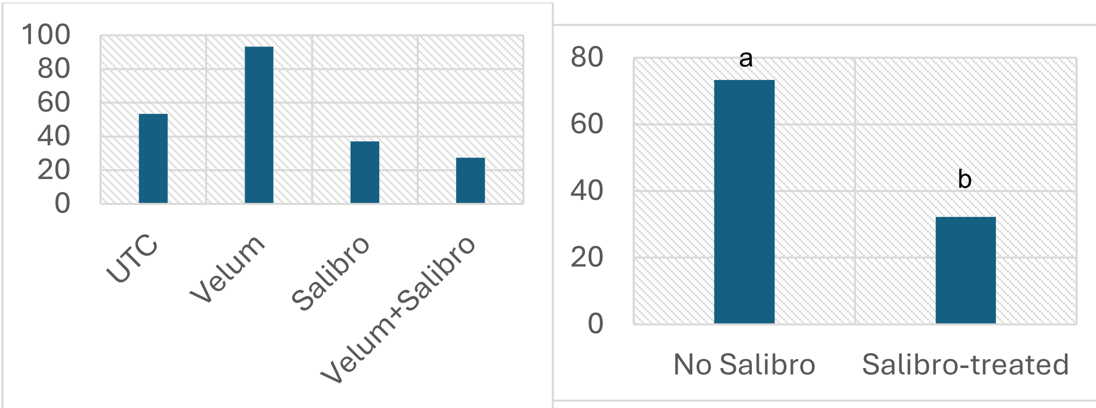

Figure 2. September *Xiphinema* readings, Trial 2. Individual treatments shown on left, grouped treatments shown on right.

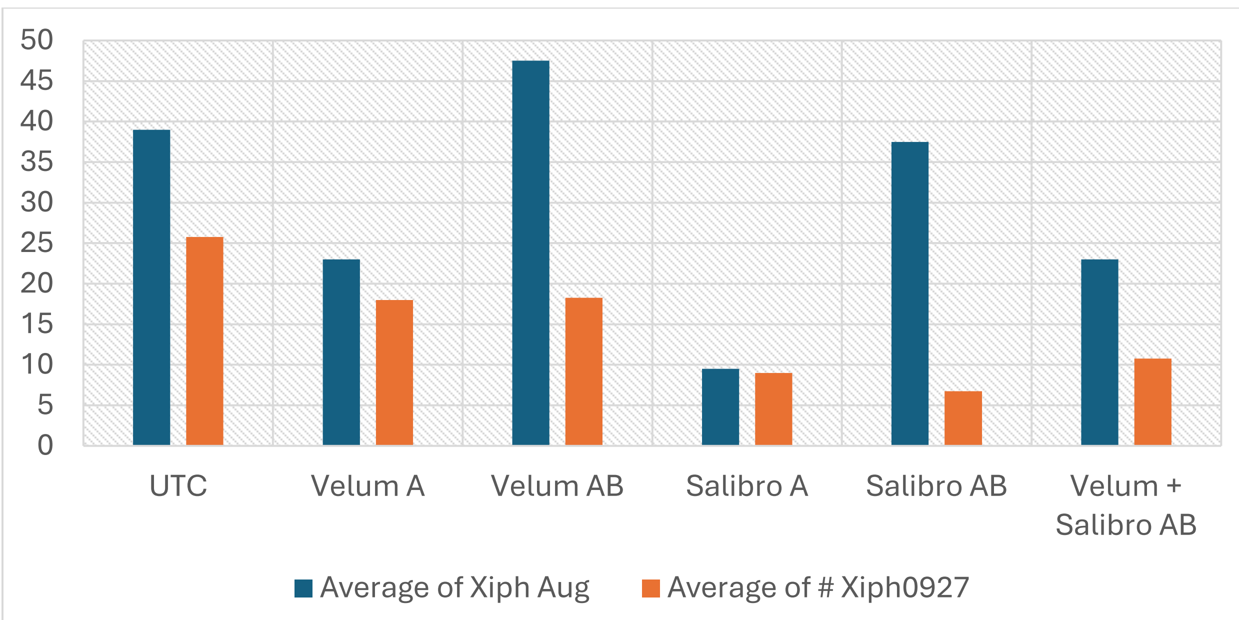

Figure 3. August and September *Xiphinema* readings, Trial 3.

2025 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

Continuing Project Proposal **Proposed Duration:** 1 year extension on two year project

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

PI:
Tom Walters
Walters Ag Research
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Anacortes WA 98221

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Cooperators:

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

Total Project Request: Year 1 $6,445 Year 2 $10,195 **Year 3 $5,445**

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. Gerbrandt, 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 Salibro (Reklemel active). Although *P. penetrans* is not a primary target of this nematicide, Corteva is supportive of this research, and willing to lend expertise and product. Salibro did not control *P. penetrans* in the first year of our study, but we want to learn whether we can use it or Velum Prime for *X. bakeri* control in raspberry.

In trials conducted in 2023 during the first year of this project, Velum Prime significantly reduced *P. penetrans* population densities when applied in June or July. Efficacy was numerically, but not statistically, better when two applications were made. Salibro did not control *P. penetrans* in the first year of our study, but we want to learn whether we can use it or Velum Prime for *X. bakeri* control in raspberry.

In 2024, we conducted three trials focusing on Dagger (*Xiphinema*) nematode control. Velum Prime was not effective on *Xiphinema,* but one or two applications of Salibro in July or August consistently reduced *Xiphinema* populations by about 50%.

This project was initially proposed as a two year project, and two years is up. If funds are available, we are proposing work in a third year because we would like to have a second year of data evaluating Salibro's effect on Xiphinema. Although Salibro is expensive (approximately $240/acre), we do not have many alternatives for dagger nematode control.

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:
Conduct two efficacy trials of Salibro on *Xiphinema*

Procedures:

Pretreatment root and soil samples will be collected June, 2025. 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 late July 2024. Additional treatments will be applied late August, according to the table below. Salibro will be applied at 61.5 fl oz/a applied through drip line, applying approximately 0.25-0.5 inches of water to the beds.

Treatment	Product	Application	Sampling
1	UTC		June, August, September
2	Salibro	July	June, August, September
3	Salibro	July, August	June, 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 *X. bakeri* numbers/100 g soil. Treatments will be considered effective if they reduce *X. bakeri* population densities one month or more after treatment.

Anticipated Benefits and Information Transfer:

- Growers will gain data on the effectiveness of Salibro in a second year.
- Data on Salibro 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: *Indirect or overhead costs are not allowed* unless specifically authorized by the Board

	2023	2024	2025
Salaries[1/]	$3,500	$3,000	$
Time-Slip	$ 500	$ 500	$
Operations (goods & services)[2/]	$1,500	$1,500	$
Travel[3/]	$ 345	$ 345	$
Meetings	$	$	$
Other[4/]	$ 600	$ 100	$
Equipment	$	$	$
Benefits[4/]	$	$	$
Total	**$6,445**	**$5,445**	**$**

Budget Justification

[1/] Walters, 3% FTE, benefits included.

[2/]Sample processing, Zasada lab

[3/]5 trips Anacortes to Lynden, 120 miles/trip, $0.575/mile

[4/] Shipping for samples, $100.

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

Project Title: Managing Cane Botrytis of Raspberry

PIs: Alan Schreiber, Researcher, Agriculture Development Group, Inc., 2621 Ringold Road, Eltopia, WA 99330, 509 266 4348 (office), 509 539 4537 (cell), aschreib@centurytel.net
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Cooperator: Lisa Jones, Pacific Berries, Lynden WA, (360) 966-6462, lisa.jones@nwplant.com

Year Initiated: 2025 **Current Year:** 2025 **Terminating Year:** 2027

Total Project Request: Year 1

Other Funding Sources: No other funding sources

Justification and Background: Botrytis cane blight, caused by the same pathogen, *Botrytis cinera,* that rots fruits, is common in Washington raspberries. Lesions can weaken or kill lateral buds and laterals. Some varieties, such as Cascade Premier, Chemainus, Kulshan and WakeHaven have experienced serious yield reduction due to this disease, when many of the fruiting laterals fail to develop. Furthermore, Botrytis cane blight produces inoculum capable of infecting growing tissues and developing fruit the following year. contributing to fruit rot losses. Cane botrytis was a more severe problem in 2024 than any year in memory. There are at least three potential reasons for this.


Figure 1. Botrytis-infected cane tied up with healthy canes. Photo by Lisa Jones, Ph.D.

First, certain new raspberry varieties appear to be more susceptible to the disease than traditional varieties such as Meeker. It is not clear if the increased problems associated with variety is due to genetically based susceptibility or the physical structure of the plant that foments disease development. Second, environmental conditions were more conducive for development of cane botrytis in 2024. Two inches of rain fell in a short period in August and in general late summer and fall of 2024 was extremely wet and promoted disease development. A third possibility is the widespread development of fungicide resistance in botrytis infecting berries.

Investigations into fungicide resistance in Botrytis (Drs. Mattupalli (WSU), DeLong (USDA)) have recently shown there is widespread resistance to fungicides in FRAC groups 7, 9, 11 and 12 in blueberries and in raspberry. This dangerous situation will seriously constrain fungicide programs for Botrytis fruit rot, especially in years when conditions favor disease. It is critical that botrytis cane blight management not exacerbate fungicide resistance in Botrytis.

Botrytis cane blight lesions typically start to appear late in July. Lesions continue to develop and expand through late summer and fall, when overwintering structures (sclerotia) develop. The sclerotia produce conidia throughout the winter and spring, spreading the fungus to new tissues. We propose to evaluate interventions at all of these stages.

Harvest treatments: Cane Botrytis lesions often begin to develop during harvest, so we will evaluate the ability of treatments (e.g., Jet Ag, Oso, PhD, Cueva, biologicals) to prevent lesions when applied during harvest.

Post-harvest cultural practices: We will evaluate effect of pruning and training time (mid August or dormant) on botrytis lesion expansion. Our hypothesis is that removing floricanes early to expose canes to sun and dry air will reduce lesion initiation and/or expansion.

Protection of new growth: We will evaluate treatments (lime sulfur, Jet Ag, Oso, PhD, Cueva, biologicals) to protect new tissue from dormancy to bloom.

Relationship to WRRC Research Priority: This project directly addresses the WRRC RFP Category "Foliar and Cane Diseases".

Objective 1. Generate data on fungicide and cultural practice efficacy against cane botrytis.

Procedures:
Harvest Treatments: Provided that we have a raspberry fruit rot Botrytis trial in 2025, we will leverage that trial to evaluate harvest treatments for efficacy against cane Botrytis. At a minimum, we will evaluate cane botrytis on treatments including Captan, Jet-Ag and PhD in the last two applications. Depending on resistance management restrictions, we may also include products with single site active ingredients, such as Merivon, Luna Tranquility or Switch. Treatments will be selected in consultation with growers, crop advisors and registrants. Frequency and size of cane Botrytis lesions will be evaluated at the end of harvest and again in mid-September

Post-harvest Treatments: We will establish a trial of post-harvest management to reduce cane Botrytis lesion initiation and/or expansion through late summer and fall. Treatments may include:

1. Removing floricanes shortly after harvest, tie primocanes to wire and apply sanitizing agent such as Jet-Ag or a protectant such as Captan
2. Removing floricanes as above, but delay tying primocanes until dormancy
3. Cut middle sections out of floricanes shortly after harvest, remove tops and tie primocanes when dormant
4. Remove floricanes and tie primocanes when dormant.

For these treatments, cane Botrytis lesion numbers and lengths will be evaluated in mid-September and again mid to late October.

Protection of new growth: We will evaluate several treatments to reduce infection of new growth from dormancy until fruit rot programs begin at bloom. Treatments and timing will be selected in consultation with growers, crop advisors and registrants as above. Our initial thoughts include: A application during dormancy, B-E biweekly from early growth until mid-May (just before bloom fungicide programs begin). Lime sulfur will be used for dormant treatments; products for other treatments will include Jet Ag, Captan, PhD and biologicals. This trial may be evaluated by rating Botrytis damage to leaves or other tissues at the beginning of bloom. It may also be evaluated by rating Botrytis damage on the blossoms, since petals are quite susceptible.

Anticipated Benefits and Information Transfer:

Our goal is to develop a set of recommendations for control of cane botrytis on raspberry. This information would be provided to growers through WRRC disseminated information, at the Washington Small Fruit Conference and at grower meetings.

Budget:	**2025**	**2026**	**2027**
Salaries [1/]	5,000	5,000	5,000
Operations	3,000	3,000	3,000
Travel [2/]	1,142	1,142	1,142
Contract Research	6,000	6,000	6,000
Benefits	2,000	2,000	2,000
Total	**17,142**	**17,142**	**17,142**

[1/] Agricultural Researcher

Contract Research --Walters Ag Research to make conduct field research

[2/] Walters—12 trips a year at 140 miles per day at $ .68 per mile = $1,142

At the time of the proposal was submitted, a request was made to Pacific Berries to donate expenses and lab capacity for the trial for Dr. Jones. Enfield Farms will donate the trial sites and cooperate with coordinating applications in the field locations.

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

Project Title: Managing Fungicidally Resistance Gray Mold in Raspberries

PI: Alan Schreiber
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Title: Researcher
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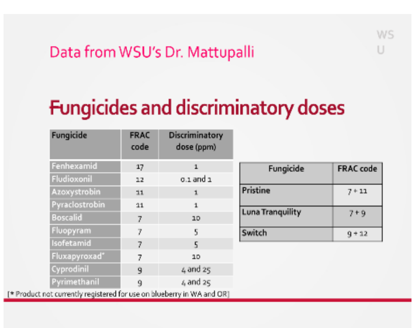
Year Initiated: 2025 **Current Year:** 2026 **Terminating Year:** 2027

Total Project Request: Year 1- $17,160

Other Funding Sources: There is no other funding support this project. We have submitted a similar proposal to the Washington Blueberry Commission but this is a separate project.

Justification and Background: *Botrytis cinerea* is one of the most destructive diseases of all berries and specifically for raspberries. Growers commonly apply six applications for gray mold in western Washington. In the 1990s and early 2000, gray mold developed resistance to iprodione. Growers switched to Elevate (fenhexamid), Pristine (boscalid), and Switch (cyprodinil and fludioxonil) and regained significant control of the disease. In 2013 widespread control failures resulted in field samples being collected and tested at the University of California Riverside for resistance. Widespread resistance was found to fenhexamid, boscalid and cyprodinil in WA, OR and BC in blueberry, blackberry, raspberry and strawberry.

Resistance management programs were quickly deployed that consisted of the following features; use of one application of iprodione, tank mixing with Captan, careful rotation of products, and integration of new fungicides including the active ingredients fluopyram, isofetamid, penthiopyrad, and pyrimethanil among other products. These resistance management principals along with weather conditions not favorable for gray mold allowed growers to manage the disease without loss of yield or reduction in quality. During this time, Dr. Jeff DeLong of USDA and WSU's Berry and Potato Pathology program (led by Chakradhar Mattupalli) continued an effort started by Dr. Tobin Peever surveying raspberry and blueberry fields for the presence of strains of *Botrytis* that contain mutations conferring resistance to FRAC group 7 (e.g., boscalid) fungicides. *Botrytis* developing resistance to FRAC group 7 fungicides is associated with multiple mutations in the *sdhB* gene. For example, an isolate of *Botrytis* with the mutation H272R renders boscalid ineffective for its control but can be controlled by other FRAC group 7 fungicides such as fluopyram or isofetamid. Likewise, an isolate with H272Y mutation can be effectively


Data from WSU's Dr. Mattupalli

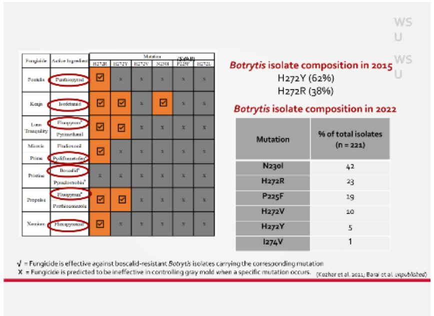
WSU

Fungicides and discriminatory doses

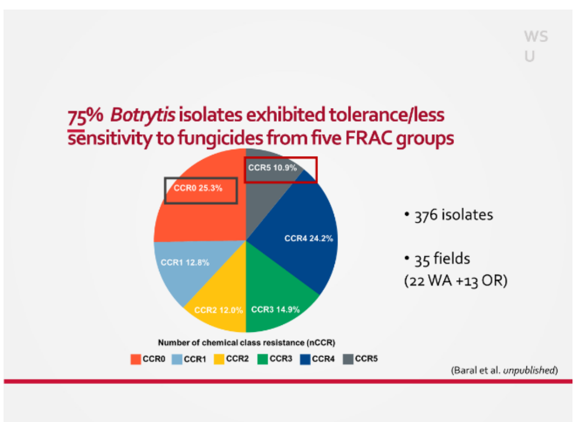
Fungicide	FRAC code	Discriminatory dose (ppm)
Fenhexamid	17	1
Fludioxonil	12	0.1 and 1
Azoxystrobin	11	1
Pyraclostrobin	11	1
Boscalid	7	10
Fluopyram	7	5
Isofetamid	7	5
Fluxapyroxad*	7	10
Cyprodinil	9	4 and 25
Pyrimethanil	9	4 and 25

[* Product not currently registered for use on blueberry in WA and OR]

Fungicide	FRAC code
Pristine	7 + 11
Luna Tranquility	7 + 9
Switch	9 + 12



managed by isofetamid and fluopyram but not by boscalid, pydiflumetofen , penthiopyrad, and fluxapyoxad (one of the active ingredients in Merivon), which is just now being registered. If an isolate of the pathogen develops resistance to a fungicide from a certain FRAC group, other fungicides from the same FRAC group also become ineffective, prior to it being exposed to the product. This is an example of cross resistance that was created by exposure to other fungicides with the same mode of action. The mutation N2301 is tolerant to FRAC group 7 fungicides such as boscalid, penthiopyrad, fluopyram, pydiflumetofen, and fluxapyroxad with the exception of one active ingredient, isofetamid (Kenja). Unfortunately, the mutations H272V andP225F have been detected in Washington blueberries and are tolerant to all FRAC group 7 fungicides listed above including isofetamid. Most importantly, data from Mattupalli's lab showed a decrease in the frequency of H272Y and H272R (5% and 23%; n = 221) mutations in *Botrytis* populations obtained from blueberry fields in 2022, compared to those reported for small fruit fields in 2015 (62% and 38%) in the PNW (Kozhar et al. 2020). They hypothesize that the introduction of fluopyram in spray programs after the 2015 survey (Kozhar et al. 2020) led to a reduction of the fluopyram-hypersensitive H272Y strains. This likely contributed to the increased frequency of N230I, P225F, and H272V mutant genotypes, which puts the efficacy of multiple SDHI fungicides at risk. Results from DeLong's research on raspberry are similar to that of Mattupalli's lab.



Mattupalli's lab evaluated the *in vitro* sensitivity of *Botrytis* isolates (n = 376 from 35 WA and OR blueberry fields) to ten fungicides (fludioxonil, fenhexamid, azoxystrobin, pyraclostrobin, boscalid, fluopyram, isofetamid, fluxapyroxad, cyprodinil, and pyrimethanil) from FRAC groups 7, 9, 11, 12, and 17. Data indicated that 75% of *Botrytis* isolates exhibited tolerance or less sensitivity (to fludioxonil) to at least one fungicide in one or more than one FRAC group. Notably, 10.9% (n = 41) of the isolates showed tolerance/less sensitivity to one of the tested fungicides from each of the five FRAC groups. Only 25.3% (n = 95) of the isolates assessed were either sensitive or moderate to all of the FRAC groups tested. The Berry and Potato Pathology program also conducted *in vitro* assays to test *Botrytis* isolates (n = 346) for their sensitivity to three premix fungicides: Luna Tranquility, Pristine, and Switch. Though greater number of *Botrytis* isolates exhibited tolerance to individual fungicides, only 4% and 44.5% of isolates showed tolerance to Luna Tranquility and Pristine, respectively. None of the isolates germinated *in vitro* when exposed to Switch at a concentration of 1 ppm fludioxonil. As fungicides in the FRAC group 7 are integral to grower spray programs, these results indicate a very alarming picture of future ability of FRAC group 7 fungicides to control gray mold in blueberries. It is very likely that in a growing season when the weather is conducive to gray mold that the growers' ability to manage the disease will be seriously compromised.

In order to most effectively manage the disease, it requires knowledge of the mutations in the pathogen population in a field, which confer resistance to FRAC group 7 fungicides. If the mutations are known, specific programs may be designed to avoid the less effective fungicides and better manage gray mold. For example, if H272R mutation is commonly present, then a program including Luna Tranquility and Fontelis should suffice. If the mutations are primarily H272Y and N2301, then a program featuring Kenja would be more effective. When *Botrytis* isolates with mutations conferring resistance against most FRAC group 7 fungicides are commonly present then increase reliance on using products that have package mixes of two different effective active ingredients such as Switch along with multisite fungicides (e.g., Captan). Increased adoption of non chemical strategies, applications targeting host susceptible stages, and careful selection of products targeting other pests that can influence resistance should be included in the management program.

It is important to point that raspberry is likely to be at a higher risk of control failures for *Botrytis* due to fungicide resistance than blueberries due to having fewer registrations (i.e. Miravis Prime) and the greater susceptibility to gray mold. Conditions do not have to be as conducive for gray mold to be a problem on raspberry. Mattupalli's work and other research have shown that package mixes or tank mixes are an important tool for managing resistance diseases and lack of access to products such as Miravis Prime for raspberry is unfortunate.

We propose to "type" two raspberry fields and determine the presence of *Botrytis* isolates with mutations that confer resistance to FRAC group 7 fungicides. Multiple programs will be designed to overcome the resistance mutations. One or two entries that are expected to fail, such as use of a Pristine reliant program will be included for comparative purposes.

- **Relationship to WRRC Research Priority:** This project directly addresses the WRRC RFP Category Fruit rot including pre harvest, post-harvest, and/or shelf life

Objective 1. Develop fungicide programs that are effective against resistant gray mold.

Procedures: Samples will be collected in early 2025, incubated to promote *Botrytis* growth followed by single sporing and sequencing to identify mutations in the *sdhB* gene that result in differential sensitivity response to FRAC group 7 fungicides. Results would be provided to Schreiber prior to pre-bloom. Schreiber will design programs for management of the disease based on what mutations are present. What the programs will be is dependent on what mutations are detected. The assumption is that first application will go out pre-bloom or early bloom followed by more applications every 10 to 14 days based on disease pressure. In a heavy pressure situation, the number of applications will be higher. The program will include mummy berry control. Including mummy berry controls is important as management of this disease can have important impacts on gray mold control outcomes. For example, use of products that contain FRAC Group 7 products (such as Pristine and Switch) for mummy berry control will influence frequency and types of resistant strains of mummy berry. The trial will be based on a randomized complete block design and the treatments will be replicated four times. The trial location is expected to be in Whatcom County. Fruit will be sampled just prior to harvest and held in a growth chamber to assess pathogen incidence based on which the relative effectiveness of spray programs will be assessed.

Anticipated Benefits and Information Transfer:

Our goal is to develop a set of recommendations for control of fungicidally resistant gray mold on raspberry. This information would be provided to growers through WRRC disseminated information, at the Washington Small Fruit Conference and at grower meetings.

Budget:

	2025	2026	2027
Salaries1/	7,000	7, 500	8000
Time-Slip			
Operations (goods & services)	500	500	500
Travel2/	850	850	850
Meetings			
Other	6,500	7000	7,500
Equipment3/			
Benefits4/	2,310	2,475	2,640
Total	**17,160**	**18,325**	**19,490**

1/Type of Personnel, Agricultural Researcher

2/ Travel to fields to make applications and make evaluations

3/Other: contract with Walters Ag Research to make applications and do plot work

4/ Benefits 33%