2024 Research Proposals

and

2023 Research Reports

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

Year	Seat	
24	1	John Clark Lynden
25	2	Andy Enfield Lynden
26	3	Mark Van Mersbergen, Pres. Lynden
23	4	*OPEN*
24	5	Brad Rader Lynden
25	6	Matt Maberry Lynden
WSDA	7	Dani Gelardi, WSDA Olympia

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2024 Research Priorities

#1 priorities

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

#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 – *moved from #3*

#3 priorities

- Thrips – understand the lifecycle, and control strategies - *new*
- Snail control – understand lifecycle and management strategies – *moved from #2*
- Root weevils
- Alternative Management Systems – fruit yield per linear foot of bed – planting densities, row spacing, trellising
- Nutrient Management – Revise OSU specs, Consider: timing, varieties, appl. Techniques, calcium, nutrient balance
- 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

PAGE	PROJECT TITLE	RESEARCHER (S)	REQUEST	DRAFT 1	
PLANT BREEDING			100.00%	#DIV/0!	
5	Red Raspberry Breeding, Genetics and Clone Evaluation	Hoashi-Erhardt	$80,160		
20	Coordinated Regional on-farm Trials	NWBF - Walters	$5,183		
26	Red Raspberry Cultivar Development	Dossett	$10,000		
35	Cooperative raspberry testing and cultivar development	Hardigan	$7,000		
	WRRC Land and Management fees		$50,000		
ENTOMOLOGY			43.57%	#DIV/0!	
55	Two-Spotted Spider Mites and Thrips in Red Raspberries	Schreiber	$12,495		
60	Thripts Identification and Biology	Nottingham	$14,095		
64	Developing an Insect IPM Program	Nottingham			
65	IPM Utilizing UAV Technology	Beckley	$25,000		
74	Management of Snails	Schreiber	$12,000		
WEEDS			12.12%	#DIV/0!	
78	Spot Spray Technology	Benedict	$11,433		
91	New Technology, Products for Raspberry Weed Management	Schreiber	$6,248		
PHYSIOLOGY			22.94%	#DIV/0!	
95	Calcium accumulation and increasing fruit uptake	DeVetter	$16,726		
100	Determining Leaf Nutrient Sufficiency Standards	DeVetter	$16,748		
PATHOLOGY/VIROLOGY			21.38%	#DIV/0!	
104	Control of Cane Blight in Red Raspberries	Schreiber/Jones	$15,000		
108	Extending the lifetime of plantings with novel post-plant nematicides	Walters	$10,195		
113	Virus Testing of PNW raspberry breeding programs	Hardigan	$6,000		
121	Characterization of Botrytis on red raspberries	Stockwell/DeLong			
SOILS					
	Total Plant Breeding		**$152,343**	**$0**	
	Total Production Research		**$145,940**	**$0**	
	Research Related	WRRC expenses	$3,000	$3,000	
	Small Fruit Center fee		$3,000	$3,000	
	TOTAL		**$151,940**	**$6,000**	
	2024 Plant Breeding Budget		$200,000	$200,000	re
		under budget	$47,657	$200,000	
	2024 Research Budget		$85,000	$85,000	
		under budget	-$66,940	$79,000	

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
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Reporting Period: 2023

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 is a very promising advanced selection that is being forwarded for release as a new cultivar, following good performance at several regional grower sites and with IQF processors in studies that leveraged WRRC funding to procure funding from the NW Center for Small Fruit Research. WSU 2188 has large fruit, good firmness, and good flavor. Its season is temporal with 'Meeker'. The patent process, cultivar description, and grower informational sheets are in progress.

WSU 2029 is a unique floricane-fruiting red raspberry selection that is being forwarded for release as a new cultivar, based on its good yields of medium large, firm, bright red fruit with good flavor; very 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. The program is working to patent and release WSU 2029 under a nonexclusive license.

WSU 1605 ('Cascade Gem') was licensed exclusively in Europe with Meiosis and plant sales were 263,000 total plants in the EU for 2020 and 2021. The program is intending to move to protect and release this in North America for fresh production. It performs well for long cane production and represents an important revenue stream to support plant breeding efforts for the industry.

Crosses, seedlings, and selections.
New crosses were performed in 2023 between parents with traits of excellent machine-harvested yield, berry firmness, and root rot tolerance. Forty-three crosses were successful, and the resulting seeds have been germinated and are being developed into seedling plugs for further tests with a grower-cooperator in Lynden.

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 2023.

Establish-ment year	Number of seedlings	Activities in 2023
2021	~ 100	Program dealt with deferred maintenance and technical staff turnover at the farm.
2022	~500	Program installed new technician at the end of August.
2023	4000	3600 seedlings were planted in Lynden with grower cooperator, 400 seedlings were planted at the WSU Puyallup Research and Extension Center (PREC) that the cooperator didn't have room for.

No new selections were made in 2023 because the 2021 seedling field was too small because of COVID-era staffing problems in 2021.

Machine Harvesting (MH) Trials - Observational. A new machine harvesting trial was planted in 2023 at Rader Farms. Two other machine-harvesting trials were maintained and evaluated for yield and fruit quality during the 2023 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; evaluated selections for the first season for fruit quality and yield to drive advancement and discard decisions. This planting will be evaluated for a second season in 2024.
2022	75 WSU + 14 ORUS selections, 3 cultivars	Planting was produced to generate primocane growth in advance of the first cropping year in 2024 and harvested in both 2024 and 2025.
2023	39 and 3 cultivars	Prepared, planted and maintained. This planting will be harvest for yield in 2025 and 2026.

The 2021 MH trial was evaluated for the first time in 2023. Several selections stood out for outstanding qualities of plant durability, yield, and fruit quality.

- Cultivars: 'Cascade Harvest' yielded 5.8 T/acre and 'Meeker' had 1.6 T/A.
- WSU 2642. This selection yielded 6.2 T/A and gave machine harvested fruit with good size, shape, color, as well as low winter injury and few disease symptoms.
- WSU 2647 yielded 7.9 T/A and had well-shaped, firm machine harvested fruit that was light red in color.
- WSU 2769 yielded 6.4 T/A and had rich red color and high firmness.
- WSU 2724 yielded 5.9 T/A and had beautifully intact machine harvested fruit with an even collar and a tight drupelet structure.

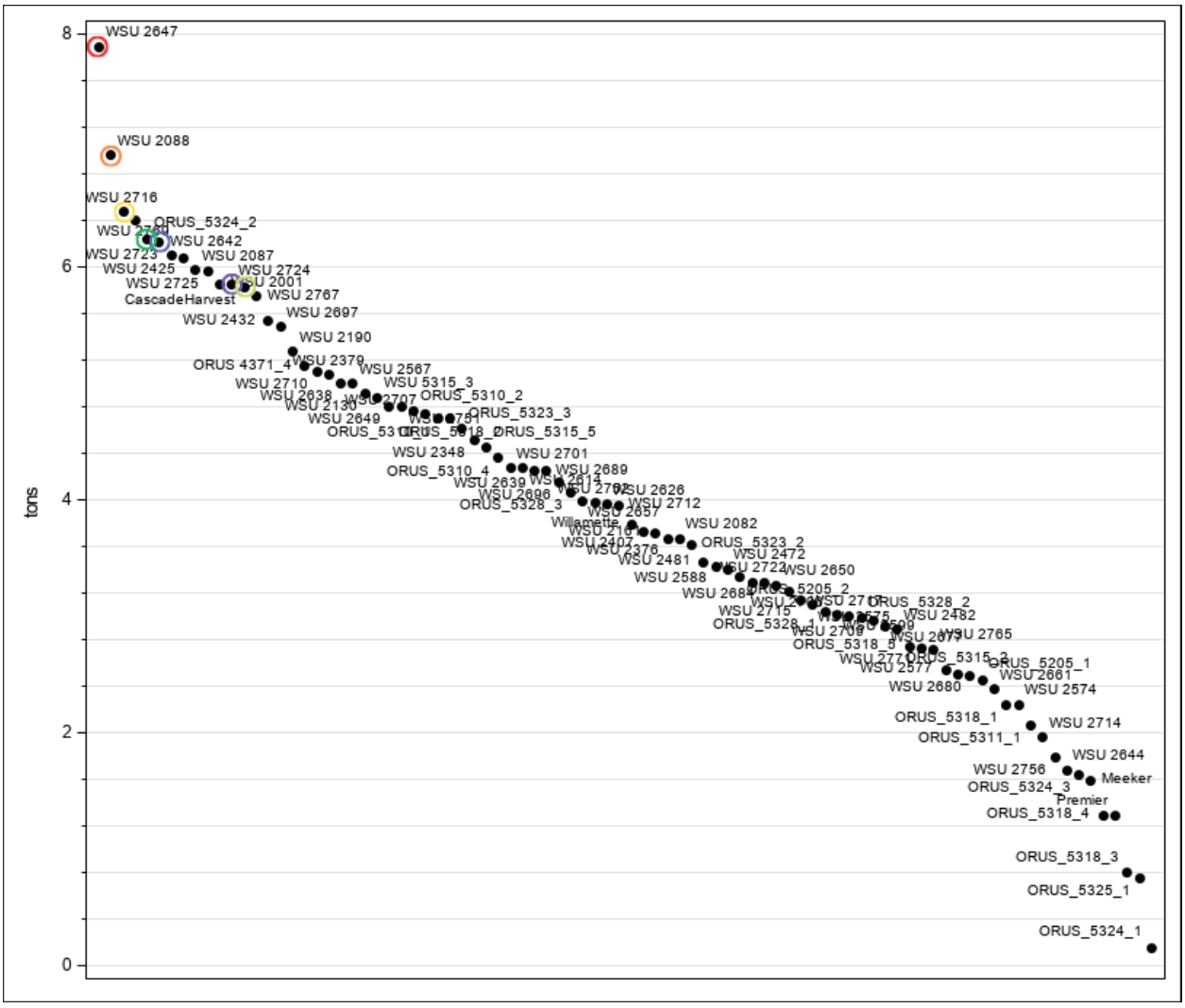

Fig. 1. Yield in tons per acre in 2023 of selections in unreplicated observational plots in the machine harvesting trial established in 2021. Selections described are indicated by colored circles in descending order: WSU 2647 (red), WSU 2088 (orange), WSU 2716 (yellow), WSU 2769 (green), WSU 2642 (blue), WSU 2724 (purple), and Cascade Harvest (lime). Yield is expressed as tons per acre assuming 1960 plants per acre.

Yield and Fruit Quality Evaluations (selection trials). A new yield and fruit quality trial was planted in 2023 at Rader Farms. Two other yield trials were were maintained and evaluated for yield and fruit quality during the reporting year 2023 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 first season for fruit quality and yield to drive advancement and discard decisions. This planting will be evaluated for a second season in 2024.

2022	8 and 3 cultivars; 3 replicates	Planting was produced to generate primocane growth in advance of the first cropping year in 2024; to be harvested in both 2024 and 2025.
2023	3 and 3 cultivars; 3 replicates	Prepared, planted and maintained. This planting will be harvest for yield in 2025 and 2026.

The selections were harvested for yield 2 or 3 times weekly (Table 4). WSU 2564 had significantly higher yields than 'Meeker' and 'Cascade Harvest'. WSU 2087 and WSU 2069 are in grower trial currently and had similar yields to 'Meeker' and 'Cascade Harvest'. 'Cascade Premier' did not establish as well as expected and had low first-season yields.

Table 4. Mean 2023 yield of 19 WSU selections and 4 cultivars with 3 replicates planted in 2021 in Lynden, WA.

Clone	Yield[z]	(tons/acre)[y]
WSU 2564	7.96	A
WSU 2087	7.28	Ab
WSU 2069	6.45	a-c
'Meeker'	6.32	a-d
'Cascade Harvest'	6.24	a-d
WSU 2088	6.03	a-e
WSU 2001	5.81	b-e
WSU 2068	5.76	b-f
WSU 2348	5.71	b-g
WSU 2130	5.52	b-h
WSU 2425	5.06	c-i
WSU 2561	4.90	c-i
WSU 2472	4.41	d-i
WSU 2376	4.22	e-i
WSU 2571	4.22	e-i
WSU 2188	3.85	f-i
WSU 2481	3.80	g-i
WSU 2482	3.78	g-i
'Willamette'	3.57	hi
WSU 2082	3.51	i
'Cascade Premier'	3.47	i
WSU 2555	3.32	i
WSU 2557	3.21	i

[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 Tukey's Studentized Range (HSD) Test at $p < 0.05$.

Grower Trials.
Five advanced selections, indicated in bold in Table 4 showing yield results from the 2021 yield trial, are also currently in grower trial on multiple sites in Washington. Each of these selections show a lot of promise for root rot tolerance, machine harvesting, yield, and fruit quality:

WSU 2130. 4 grower sites, very high yielding in Puyallup, North Willamette, and Enfield's over two harvest seasons. At heavy root rot site, saw some effect on growth in 2022. Early ripening season, similar to 'Willamette', with firm, attractive, conic, medium sized fruit. Good winter hardiness.

WSU 2068. 3 grower sites, high yielding, early season selection with large berries with good firmness. Tolerant to root rot, appears to have better field tolerance than 2069. Very good winter hardiness. Early fruiting, full canopy, good flavor.

WSU 2069. 3 grower sites, high yielding, early season selection, large berries with good firmness. Very good winter hardiness, and early. Flavor not quite as good as 2068. Canes white with cane Botrytis at one location. Root rot tolerance also not quite up to the level of 2068.

WSU 2088. 4 grower sites, high yields at 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. 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.

A subset of selections in the replicated yield trial were evaluated for horticultural traits by Lisa DeVetter's small fruit horticulture program on 18 August 2023 with averages presented below in Table 5. Overall, all advanced selections and 'Cascade Premier' demonstrated greater vigor than 'Meeker'. Yield potential in terms of lateral length and flower/receptacle remnants per lateral were also on average higher for all advanced selections and 'Cascade Premier' relative to 'Meeker'. 'Meeker' also had visibly more spines. These data indicate the WSU selections are showing high yield potential and gains relative to 'Meeker'. Observationally, WSU 2088 had visibly more ripe fruit on lower laterals indicating a longer production window.

Table 5. Average primocane height, number of primocanes per plant, node number, internode distance, lateral length, flower/receptacle remnants per lateral, and spininess of advanced selections relative to 'Meeker' and 'Cascade Premier' red raspberry. Lateral data were collected from one representative lateral per plant emerging near the top trellis wire.

Selection/cultivar	Primocane height (in)	Primocane number/plant	Node number	Internode distance (in)	Lateral length (in)	Flowers per lateral	Spininess (1-5)[z]
WSU 2087	72.2	12	28.3	2.6	14.1	14	2
WSU 2088	74.9	15	29.3	2.6	19.7	12	1.5
WSU 2130	71.1	9	23.8	3.0	14.4	12	1.5
Meeker	62.6	7	31.0	2.0	10.2	9	4
Cascade Premier	84.2	12	31.8	2.7	19.9	10	3

[z]Spineness rated on a scale of 1-5 with 1 = no spines, 5 = very spiny, 3 = intermediate; assessed mid-length on primocane.

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 2021 planting are included in Table 6. Table 7 outlines accomplishments for root rot evaluations.

Table 6. Root rot response in 2023 of WSU selections and standard cultivars planted in 2021 in a root rot infested area at PREC.

Selection	Rating 2022[z]	Rating 2023
	Replicated	
WSU 2561	3.5	3.3
WSU 2472	2.8	3.0
WSU 2481	2.5	2.3
WSU 2599	2.3	2.3
WSU 2082	1.5	2.0
WSU 2376	1.5	2.0
'Meeker'	**2.3**	**1.0**
WSU 2432	0.8	1.0
WSU 2088	0.5	0.3
WSU 2348	0.5	0.0
	NS[y]	*NS*
	Non-replicated	
WSU 2555	4.3	4.5
WSU 2087	3.5	3.0
WSU 2130	3.0	3.0
WSU 2567	2.5	2.5
'Wakefield'	**2.5**	**2.5**
'Cascade Harvest'	**2.5**	**2.3**
WSU 2366	2.0	2.0
WSU 2425	1.8	2.0

WSU 2001	2.3	1.8
WSU 2482	0.8	1.0
WSU 2574	0.5	1.0
WSU 2613	0.8	1.0
WSU 2379	0.5	0.8
WSU 2614	0.0	0.0

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

[y]Non significant at $P < 0.05$ of Tukey's Studentized Range Test.

Table 7. Accomplishments, tasks, and highlights for root rot evaluation trials.

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

Collaborative genetic research. A second 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 National Clonal Germplasm Repository. The nematode response is being evaluated phenotypically over three years. Genotyping-by-sequencing information is being 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.

Publications/Presentations

Hoashi-Erhardt, W.K. 2023. Raspberry Plant Breeding for the Pacific Northwest. North American Raspberry and Blackberry Association conference, virtual, 23 January 2023.

Hoashi-Erhardt, W.K. 2023. Raspberry Plant Breeding in Washington. Oregon State University Caneberry Field Day, Aurora, OR, 29 June 2023.

Hoashi-Erhardt, W.K. 2023. Raspberry Plant Breeding for Machine Harvesting. Washington State University Field Day, Lynden, WA 13 July 2023.

Hoashi-Erhardt, W.K. 2023. Raspberry Plant Breeding for Machine Harvesting. ISHS Rubus and Ribes Symposium Tour, Lynden, WA, 16 July 2023.

Hoashi-Erhardt, W.K. 2023. Raspberry Breeding Lightening Update, Small Fruit Conference, Lynden, WA, 30 Nov 2023.

2024 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

Continuing Project Proposal Proposed Duration: 1 year
PROJECT: GR00011770
TITLE: Red Raspberry Breeding, Genetics and Clone Evaluation
CURRENT YEAR: 2023

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

Cooperators: Northwest Berry Foundation; Michael Hardigan, Mary Peterson, 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:** 2023 **Terminating Year:** continuing

Project Request: $ 80,160

Other funding sources:
Agency Name: Northwest Center for Small Fruits Research
Amt. Awarded: $50,000
Notes: Funds will be used to provide partial technical support for the program.

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

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

Justification and Background: Washington's growers are leaders in the production of the processed red raspberry in the U.S. 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 with high 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 WSU genotypes for IQF quality and examining the potential for genomic selection for root lesion nematode resistance, an economically important pest to raspberry production.

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

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

Anticipated Benefits and Information Transfer: The program will continue annual plant breeding activities that lead to genetic gain and the potential for elite red raspberry selections to become cultivars. Additionally, the program will preserve germplasm, develop cooperative 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.

Procedures

1. Crosses and seedling propagation. PREC. Cross parents likely to produce progeny with excellent traits. Status: Crosses, spring 2024; seedling propagation, Sept 2024 to spring 2025.
2. Seedlings. Germinated seeds from crosses, plant, grow for 2 years and identify excellent individuals (selections) to enter cultivar development pipeline. Status: Seedlings from 2023 crosses will be established in 2024 with Brad Rader with separate WRRC funds.
3. Observational machine harvest (MH) trial. Lynden. New selections are propagated and tested for machine harvestability, yield, and fruit quality. Status: 2021 and 2022 MH trial at Honcoop's will be evaluated in 2024; 2023 MH trial maintained for eval next year; 2024 MH trials will be established with Brad Rader under separate WRRC funding.
4. Replicated yield trial. Lynden. Selections that have performed well in the observational MH trial are evaluated in replicated plots for yield and fruit quality. Status: 2021 and 2022 rep trial will be evaluated for yield and fruit quality; 2023 rep trial will be maintained for evaluation next year; 2024 planting to be planted in spring with Brad Rader under separate WRRC funding.
5. Root rot trial. PREC. Root rot response is evaluated in comparison with standard cultivars for 3 years. Status: Root rot plots planted in 2021, 2022, and 2023 will be maintained and evaluated for tolerance in 2024. A new planting will go in in 2024.
6. 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. WRRC funding supports propagation and transport of WSU material, but all costs of planting and evaluation are borne by other programs.
7. Grower Trials (Advanced stage). Walters, Pond/NBF. Three to four elite selections will be propagated, tested for virus, sent to the nursery, then tested by growers to assess for yield, fruit quality, and traits important to commercial production, like establishment, water use, disease susceptibility, and winter hardiness. WRRC supports propagation, virus testing, and coordination required for selections to get to nurseries and growers.
8. Propagation (supporting). PREC. Generate multiple plants of single, genetically unique selections through tissue culture and greenhouse methods for all the plantings listed above. Year-round management of laboratory, personnel, greenhouse, and supplies.
9. Germplasm (supporting). PREC. Maintain and preserve core and experimental germplasm. Key for cultivar integrity and tracing. Also crucial for introgressing important traits from diverse Rubus germplasm. Year-round management of germplasm in tissue culture, screenhouse stock plants, field stock plants.
10. Virus testing (supporting). PREC, Mollov, Lake USDA. Propagate, initiate testing, and maintain records on selections and propagules and their virus status for timely propagation for grower trial. Year-round management of records and selection propagation status, collaboration with virologist at USDA.

Budget:

Budget		2024-2025
Salaries - 00		$ 22,202
Plant Technician (0.37 FTE)	$ 20,433	
Ag. Res. Tech. 2 (2 wks)	$ 1,769	
Time-slip Wages - 01		$ 20,120
Goods/Services - 03		$ 21,500
Machine harvest trials, including rep. yld trial	$ 15,000	
Land use fees	$ 500	
Supplies	$ 6,000	
Travel - 04		$ 2,400
Benefits - 07		$ 13,938
Total Direct Costs		**$ 80,160**

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, 0.37 FTE ($20,433).
Agricultural Research Technologist 2 (ART2)– NWREC. ART2 Emma Rogers will collect data and process fruit samples for 2 weeks full time in summer 2024 ($1,769).
Non-permanent scheduled ART2 - PREC. An ART2 will conduct tissue culture and greenhouse propagation, at a wage of $22/hr for 10 hrs/week for 50 weeks ($11,000)
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 $10,958 for 0.37 FTE. ART2 benefits for Emma Rogers amount to $928. Non-permanent classified staff benefits amount to $2,052.

Goods and Services.
Machine harvesting (MH) trials**.** Cooperating grower is paid as a service contractor to maintain MH trial, harvest plots, and communicate with researcher. Total is $15,000.
Land use fees. WSU farm services for plant breeding fields, 5 acres at $100/acre ($500).
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 $.655/mile x 6 trips - $1,179) in one year, and 5 nights in a hotel in Lynden (5 x $120 = $600), plus local mileage for PIs and employees amounting to 948 miles ($621).

Current Support

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of time committed	Title of Project
Hoashi-Erhardt	Northwest Center for Small Fruit Research	$50,000	2023-2024	10%	Small Fruit Breeding in the Pacific NW
Hoashi-Erhardt, DeVetter	Washington Red Raspberry Commission	$73,965	2023-2024	20%	Red Raspberry Breeding, Genetics and Clone Evaluation
Hoashi-Erhardt	Oregon Strawberry Commission	$6,392	2023-2024	2%	Genetic Improvement of Strawberry
Hoashi-Erhardt, Zasada, Hardigan, Dossett	Northwest Center for Small Fruit Research	$135,236	2021-2024	5%	Genomic Prediction for Quantitative Resistance to Root Lesion Nematode in Raspberry
Hoashi-Erhardt, Luby, Watson, Winfree, Pond	Northwest Center for Small Fruit Research	$46,795	2022-2024	3%	Assessing the current state and stewarding the future of Pacific NW strawberry production, econ., and breeding

Pending Support

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of time committed	Title of Project
Hoashi-Erhardt	WSDA SCBG	$200,000 (est.)	2024-2027	10	Novel and valuable raspberry plant breeding datasets leading to newcultivars and molecular breeding tools
Hoashi-Erhardt, DeVetter	Washington Red Raspberry Commission	$80,160	2024-2025	20%	Red Raspberry Breeding, Genetics and Clone Evaluation

Name: Lisa Wasko DeVetter

Instructions:

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

NAME (List.PI #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
Iorizzo, M., P. Munoz, J. Zalapa, N. Bassil, D. Main, D. Chagne, L. Giongo, K. Gallardo, E. Canales, A. Atucha, L.W. DeVetter	USDA NIFA SCRI	$7,900,000	9/2019-8/2023	3%	VacciniumCAP: Leveraging genetic and genomic resources to enable development of blueberry and cranberry cultivars with improved fruit quality attributes
Isaacs, R., R. Mallinger, L. DeVetter, S. Galinato, P. Edgar, and A. Melathopoulos	USDA NIFA SCRI	$4,000,000	10/2020-9/2024	10%	Optimizing blueberry pollination to ensure future yields
Gramig, G., L.W. DeVetter, S. Galinato, D. Bajwa, and S. Weyer	USDA OREI	$1,354,554	10/2021-9/2025	5%	MulchH_2O: Biodegradable composite hydromulches for sustainable organic horticulture
DeVetter, L.W., C. Luby, C. Mattupali, J. DeLong, V. Stockwell, and S. Lukas	Washington Blueberry Commission (WBC)	$13,480	1/2022-ongoing	5%	Evaluating new blueberry cultivars and advanced selections in the Pacific Northwest
DeVetter, L.W. M. Hardigan, and D. Bryla	Washington Red Raspberry Commission (WRRC)	$60,386	1/2021-12/2024	3%	Calcium accumulation and increasing fruit uptake in floricane raspberry
Bryla, D. and L.W. DeVetter	Northwest Center for Small Fruits Research	$180,000	5/2022-4/2025	2%	Calcium application and its effect on yield and fruit

					quality of blueberry, raspberry, and blackberry
Morandin, L., K. Rourke, A. Melathopoulos, L.W. DeVetter, R. Isaacs, and T. Ricketts	USDA Multi-State	$554,436	4/2022-3/2025	5%	Optimization of habitat to support pollinators and reduce pests: Removing barriers to habitat adoption in highbush blueberry
DeVetter, L.W., D. Bryla, D., M. Hardigan, M. Zamora Re, K. Gallardo, S. Galinato, and W. Hoashi-Erhardt	USDA Multi-State	$717,637	10/2022-9/2025	10%	Beat the heat - Mitigating heat damage in caneberry
DeVetter, L.W., K. Englund, T. Marsh, J. Goldberger, S. Agehara, and S. Sistla	USDA NIFA SCRI	$8 mil	9/2022-10/2026	15%	Improving end-of-life management of plastic mulch in strawberry systems
Borghi, M., L.W. DeVetter, P. Edger, M. Iorizzo, R. Schaeffer, R. Sagili, and V. Kulyukin	USDA NIFA SCRI	$50,000	10/2023-9/2024	5%	Harnessing blueberry flower chemistry and metabolism to boost pollination and bee health
Xuejun. P., Y. Yuan, T. Li, and L.W. DeVetter	USDA NIFA AFRI	$1,000,000	1/2023-12/2025	5%	Biobased, fully soil-biodegradable mulch films prepared from biomass for sustainable bioeconomy
DeVetter, L.W., C. Kogan, D. Crowder, and S. Galinato	Washington State Department of Agriculture Specialty Crop Block Grant (WSDA SCBG)	$191,229	9/2023-9/2026	3%	Beyond honey bees: Building towards resilient pollination for blueberry
PENDING:					
Wei, Y., J. Davidson, C. Li, J. Chen, A. Deltsidis, J. Vander Weide, Z. Rubio Ames, C. Grimm, T. Delbridge, S. Lukas, Q. Wang, F. Takeda, W. Stone, and L.W. DeVetter	USDA NIFA SCRI	$4,000,000	10/2024-9/2028	5%	Advancing machine harvest technologies for fresh market blueberries
DeVetter, L.W. and D. Bryla	WRRC	$35,583	1/2024-12/2025	3%	Developing tissue nutrient standards for raspberry

Hoashi-Erhardt, W. and L.W. DeVetter	WRRC	$80,160	1/2024-12/2025	2%	Red raspberry breeding, genetics, and clone evaluation
DeVetter, L.W. and S. Mantle	WBC	$11,973	1/2024-12/2024	2%	A BerrySmart idea: Validation and optimization of tech tools for Washington blueberry growers
DeVetter, L.W. and C. Kogan	WSDA SCBG	$248,324	9/2024-9/2027	2%	Winter is coming: Predicting and mitigating freeze damage in raspberry and blackberry

2023 contract #9
Title: On-farm Trials of Advanced Raspberry Selections

Personnel: PI: Tom Walters, Walters Ag Research. Co-PI's: Julie Pond, Northwest Berry Foundation; Michael Hardigan – USDA-ARS-HCRU; Wendy Hoashi-Erhardt – Washington State University; Julie Enfield – Northwest Plant Company.

Reporting Period: 2022-2023

Accomplishments:

- Detailed on-farm information on harvestability, disease susceptibility and cultural management on WSU 2188 compiled; this selection is to be released very soon.
- Additional information on WSU 2069, WSU: 2087, WSU 2088, WSU 2130 compiled, informing the decision to advance (possibly WSU 2087) or hold back (WSU 2069) selections.

Results:
Conducted year 3 evaluations of 2020-planted trials, including vigor, uniformity, winter injury. Cane Botrytis, canes per hill, fruit quality and machine harvestability. There are four small-plot trials, each with 3-7 entries. In 2021, two large (over 2 Acre) plantings of WSU 2188 were established, as was a 1-row trial of WSU 2087. Results are summarized below:

WSU 2188

- Long fruiting laterals break, especially in the first harvest year. Manage vigor.
- Outstanding fruit quality, excellent for IQF processing.
- Winter Hardiness intermediate between WakeHaven® and Cascade Premier
- Moderately susceptible to cane botrytis
- 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

WSU 2069

- High-yielding, firm, early fruiting selection
- Winter hardy
- Root rot resistant
- Druplets on some plants are irregular and rough-looking
- Cane Botrytis similar to Cascade Premier
- Do not advance yet; possible re-evaluate once drupelet issue resolved

WSU 2088

- Excellent yield potential, 24+ fruits/lateral
- Fruit firm, uniform, attractive on harvester
- Slightly less winter hardy than 2087
- Less cane Botrytis than Cascade Premier
- Purplish color to fruit

WSU 2087

- Very good early yield potential
- Vigorous plants, thick primocanes. More compact than 2188
- Fruit large, rounded, consistent size
- Less Cane Botrytis than Cascade Premier

WSU 2130

- Compact plants, fruit presented outside canopy
- Good yield potential, 15-25 fruits/lateral
- Winter hardy
- Did not perform well under heavy root rot pressure
- Less cane Botrytis than Cascade Premier

Publications:

- Variety update, Small Fruit update, Jan 2023.
- Presentation at Small Fruit Conference, Lynden WA Nov 30 2023

2024 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

Project Proposal **Proposed Duration:** 3 years

Project Title: On-farm Trials of Advanced Raspberry Selections

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

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

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

Year Initiated 2024 Current Year 2024 Terminating Year 2026

Total Project Request: 2024: $5,183

Other funding sources:

In-kind contributions: $1200 (estimated 800 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.

This year's proposed work will continue evaluation of elite selections from the WSU and USDA raspberry breeding programs in Whatcom county growers' fields. The program will evaluate trials established 2020 and 2021, including 4 trials with 50-150 plants each of 3-6 selections in each trial, as well as two 2-4A trials of WSU 2188 for IQF evaluation. We will coordinate trial management with growers, collect trial data directly and through the grower-cooperators, and disseminate trial findings to the industry at meetings, through the Small Fruit Newsletter and elsewhere. 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 canebery production and pest management, along with local expertise in Whatcom county and BC, and a well-developed, well-read vehicle for information dissemination (the Small Fruit Newsletter). We will coordinate the Washington Trials with trials in Oregon and with Eric Gerbrandt's trials with the BC Berry Council.

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

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

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

Objectives:
In 2024, 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 (two plantings, 2-4 A each), 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 2024.

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

	2024
Salaries[1/]	**$3,000**
Travel[2/]	**$458**
Outreach[3/]	**$1,500**
Other (Propagator payments**)**[4/]	**$ 000**
Offices costs (to NBF**)**	**$ 225**
Total	**$5,183**

Budget Justification

[1/] **Salaries**

Tom Walters—3%FTE, including benefits = $3,000

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

Tom Walters—5 trips a year at 140 miles per day at $ .655 per mile = $458

[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 2024.
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 2023 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: 2023

Accomplishments:

- Established ~6,000 seedlings in the field
- Established a new machine-harvest yield trial (110 genotypes replicated)
- Harvested and evaluated seedlings (~7500 genotypes)
- Made 79 new selections for further evaluation
- Established BC 1855.14 and BC 1855.37 in large-scale trial plots for evaluation of IQF potential
- Harvested and evaluated yield-trials (2019, 2020, and 2021 plantings)
- What has been contributed to science and/or the industry?

Results:

Unfortunately, we were only able to machine-harvest our yield trial plots until July 21. After this date, we had to handpick plots. Because we did not have sufficient labor to handpick all of the yield trials, we made the decision to hand harvest the most interesting/advanced selections as well as the cultivar standards from the yield trials so that we could have a full set of replicated data on these selections. Because we were able to machine-harvest these trial plots up until this date, we were able to get a decent evaluation of machine-harvest potential for all of the selections in trial, but we only have data for yield for the following:

<u>2020 planting</u>

Chemainus: 5.6 t/a; Meeker: 3.8 t/a; BC 10-71-27: 5.6 t/a; BC 10-79-33: 7.7 t/a; BC 10-84-9: 6.3 t/a; BC 1653.7: 6.8 t/a. BC 10-71-27 and BC 1653.7 both stood out for their earliness and both had nice quality fruit at harvest, with BC 10-71-27 a little firmer.

<u>2021 planting</u>

Chemainus: 5.9 t/a; Meeker: 4.7 t/a; BC 1855.11: 7.4 t/a; BC 1855.14: 8.3 t/a. BC 1855.11 was particularly impressive for its fruit quality and ease of machine harvest. It starts about 7-10 days later than Meeker and Chemainus, though in our plots this summer, 95% of the fruit was harvested in a 21-day window from July 13-August 4. BC 1855.14 also had very nice fruit quality and very strong yields over a similar period as ‘Meeker’ and ‘Chemainus’, starting a couple of days later and continuing a few days longer as well.

NOTE: Limit annual Progress Report to one page and Termination Report to two pages, except for publications.

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
time must be listed whether or not salary for the person(s) involved is included in the budgets of the various p
3. Provide analogous information for all proposed research which is being considered by, or which will be su
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	$1,832,010	April 1, 2023 – March 31, 2028	60%	Blueberry Germplasm and Culti Development for the Pacific No
	AAFC, WRRC, RIDC, LMHIA	$1,068,672	April 1, 2023 – March 31, 2028	35%	Red Raspberry Germplasm and Development for the Pacific No
	AAFC, BCSGA, LMHIA	$152,667	April 1, 2023 – March 31, 2028	5%	Strawberry Germplasm and Cul Development for the Pacific Northwest

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

2024 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 2024 Terminating Year 2025

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

Other funding sources: *(If no other funding sources are anticipated, type in "None" and delete agency name, amt. request and notes)*
Agency Name: Funding is being requested from the Province of BC, Raspberry Industry Development Council, Lower Mainland Horticultural Improvement Association, Agriculture and Agri-Food Canada for funding raspberry work (also pursuing funding from BC Blueberry Council, BC Strawberry Growers' Association, to support the blueberry and strawberry portions of our work).

Amt. Requested: $3,053,350 ($1,068,672 for raspberries, see note below)
Notes: We have submitted our project to Agriculture and Agri-Food Canada's "Sustainable Canadian Agricultural Partnership" program for funding through March 2028. We anticipate that we will hear from them regarding our application, sometime in the first quarter of 2024. 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 $3,053,350, with $1,068,672 of this for the raspberry work. Based on the program guidelines, we are anticipating that our project will be eligible for a 1:1 matching ratio of government:industry funding. the funding we are asking from WRRC will 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 are making new crosses, selecting from previous selections and discarding selections which don't make the grade during testing.

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

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

Anticipated Benefits and Information Transfer: (100 words maximum)
Specific benefits that will result from this project include:

- Continued development of new cultivars and selections that will provide alternatives for producers with high fruit quality and improved yield and resistance to pests and diseases.
- Continued development of technologies that will assist this and other breeding programs to more efficiently select promising genotypes in the future.

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

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.

Progress Report
Washington Red Raspberry Commission

Project No: TBD

Title: Cooperative raspberry cultivar development program

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

Reporting Period: 2023

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

We have continued to test USDA and WSU raspberry selections to assess their performance including yield and machine-harvested fruit quality in the northern Oregon trials at OSU-NWREC (Aurora, OR). We have generated results from replicated field trials showing that several WSU red raspberry selections that are of interest to growers, including WSU 2130, WSU 2088, and WSU 2188, were among the top performing red raspberry individuals in Oregon.

In 2023 we generated a second year of replicated trial data on several selections that are of interest to the WSU breeding program: WSU 2087, WSU 2069, and WSU 2472 (Table Ry-FL 1). WSU 2087 and WSU 2069 showed excellent performance in terms of both machine harvest yields and fruit quality compared to other selections in 2022. Both selections showed higher yields in 2023 than 2022. WSU 2069 shows good firmness and excellent druplet coherence, flavor, and appearance. WSU 2087 has round berries with darker fruit color and exceptional fruit firmness, although not as attractive as WSU 2069 due to somewhat dull appearance. WSU 2087 showed the highest average yields. WSU 2472 more than doubled its yields from 2022 to 2023, showing it may benefit from additional establishment time. WSU 2472 showed great color, gloss, and flavor, but might not be firm enough for machine harvests, possibly better for fresh.

Among the USDA selections, we observed three that stood out during their first year in the 2021 trial planting (Table Ry-FL 2). In particular, ORUS 5310-1 exhibited the highest yields of any raspberry plots at the OSU-NWREC, which was combined with an early ripening season and excellent fruit quality. ORUS 5329-1 exhibited a combination of large fruit size with exceptional firmness and coherence on the machine harvester and excellent shape, color, and gloss. ORUS 5329-1 is very early and most fruit could be harvested in June. We identified another floricane selection, ORUS 5323-2, with possible fresh market potential based on its high firmness and pink lemonade appearance. These selections will be rotated into replicated plots in 2024 for further testing and evaluation in 2026. ORUS 4974-1 and ORUS 4715-2, which respectively showed the highest and second highest yields in the 2019-planted trial, demonstrated better stress tolerance and fruit quality than other selections and ‘Meeker’ during the 2021 “heat dome” and are in the process of being made available at nurseries (North American Plants, Inc.). ‘Finnberry’ is a primocane-fruiting variety release from the breeding program in 2023. Tested as ORUS 4716-1, it is a primocane cultivar with good yields of

fruit with excellent flavor and fresh market quality. 'Finnberry' is available at North American Plants, Inc. and Skagit Valley Horticulture.

Results:
We have continued to move forward on the cultivar development strategy proposed to WRRC prior to 2023. In 2023 we attempted 36 successful crosses and made no selections due to lack of crosses in 2020 (no breeder in 2021), and planted ~1,975 new seedlings from crosses made in 2022. Below are some highlights from our program for 2020. Appendix II tables contain specific information on selections.

Released:

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

Available Selections & Grower Trials

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

Floricane-fruiting:

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

Primocane-fruiting:

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

Other:

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

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

Grower Trials – Washington; Enfield Farms
We have not received 2023 trial results from Enfield Farms yet.

- **ORUS 5106-1** (nursery list) has to-date produced first-year yields similar to 'Meeker' with small, firm fruit that machine harvested well.

Grower Trials – Washington; Honcoop Machine Harvest

Since 2001, we have actively trialed OR red raspberry selections at Enfield Farms (Lynden, WA), which sits on the Canadian border, to evaluate winter hardiness and machine harvestability in a commercial setting. Most but not all selections have been machine harvestable.

- **ORUS 5104-2 (recent)** has shown good plant health, vigor, and high yields of fruit that machine harvest well. Main drawback is fruit are on the lighter-colored side.
- **ORUS 5315-3 and ORUS 5315-5** showed excellent machine harvest fruit quality with high yields of berries with good shape, color, firmness, coherence, and flavor, although yields were lower than 'Cascade Harvest'. Berries were similarly attractive with high machine harvested fruit quality in Oregon in 2023.

Grower Trials – Oregon (OSU-NWREC)

Floricane red raspberry performance and fruit quality in 2023 was excellent. Fruit quality in the OSU-NWREC machine harvest trial was easily the best observed since 2020. In the second harvest year of the 2020 trial plots, fruit size was 62% larger in 2023 compared to 2022 and yields were 71% higher in 2023 compared to 2022. In addition to larger fruit size and higher yields, average berry quality was noticeably improved with visibly better drupelet cohesion and reduced shattering and leakage. Among the USDA material, several non-replicated selections showed promise in 2023 in the newest trial planting (**Table Ry-FL 2**). In particular, ORUS 5310-1 exhibited the highest yields of any plots at the OSU-NWREC, which was combined with an early ripening season and excellent fruit quality. ORUS 5329-1 exhibited a combination of large fruit size with exceptional firmness and coherence on the machine harvester and excellent shape, color, and gloss. We identified another floricane selection, ORUS 5323-2, with possible fresh market potential based on its high firmness and pink lemonade appearance. These selections will be rotated into replicated plots in 2024 for further testing and evaluation in 2026.

2020 Floricane Red Raspberry Trials (Table Ry-FL 1)

- **WSU 2087 (REP)** showed the highest average yields for replicated selections in 2022-23. Fruit are dark, round and firm, better than 'Wakefield'. Main drawback was significant stem matter came off with the fruit during machine harvest.
- **WSU 2069 (REP)** was similarly productive to WSU 2087 and produced very attractive fruit with good color and great flavor, though lower firmness. Quality was overall quite good. Observed that firmness and coherence tailed off on warmer days and in late season, and fruit took on dusty appearance if left to hang.

2021 Floricane Red Raspberry Trials (Table Ry-FL 2)

- **'Meeker' (RED)** was the highest yielding replicated selection in 2023.
- **Several selections in held in observation were significantly higher yielding than 'Meeker' and will be moved into REP and WSU trials in 2024**
- **ORUS 5310-1 (OBS)** showed very high yields combined with early season production. Produced relatively large berries with very beautiful shape, color, gloss. Firmness was good but not exceptional. Berries still released well and held up well on machine due to good drupelet coherence.
- **ORUS 5329-1 (OBS)** was high yielding and produced the most attractive berries observed on the machine harvester in 2023, with great combination of high gloss, firmness, and coherence. Very nice fruiting laterals. Flavor good but not outstanding.

Progress Report
Washington Red Raspberry Commission

Project No: TBD

Title: Cooperative raspberry cultivar development program

Personnel:
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2021 Floricane Red Raspberry Trials (Table Ry-FL 2)

- **'Meeker' (RED)** was the highest yielding replicated selection in 2023.
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- **ORUS 5329-1 (OBS)** was high yielding and produced the most attractive berries observed on the machine harvester in 2023, with great combination of high gloss, firmness, and coherence. Very nice fruiting laterals. Flavor good but not outstanding.

- **ORUS 5323-2 (OBS)** is a floricane-fruiting selection with potential fresh market value. High yielding with strong fruiting laterals, produces berries with a lighter color that had tremendous firmness, coherence and good flavor.

2020 Primocane Red Raspberry Trials (Table Ry-PF 1)

- **'Finnberry' (REP)** set fruit and ripened very late to a degree that many did not finish ripening during the regular harvest season. Still healthier and more productive than most other selections. Fruit quality and flavor were very good as usual.
- **ORUS 4487-1 (OBS)** continued to look good as an early season and high yielding advanced selection. Fruit are firm and consistent with great flavor and color. On the smaller side (size similar to 'Heritage') but otherwise a good fresh market raspberry.
- **ORUS 5345-1 (OBS)** produced very high yields of fruit with excellent color and flavor but low firmness and coherence.

2021 Primocane Red Raspberry Trials (Table Ry-PF 2)

- **'Finnberry' (OBS)** showed poor plant health and lower productivity in 2021 trial planting.

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 Environments: Mapping Che Genetics, and Growing Cond Flavor
DeVetter, Bryla, **Hardigan**, Hoashi-Erhardt	USDA Specialty Crop Multi-State Program	$1,000,000	09/2023/09/2026	10%	Beat the Heat - Mitigating He Caneberry
Hardigan, Luby	USDA-Northwest Center for Small Fruit Research	$50,000	09/2022-09/2023	10%	Evaluating the potential of ge predicting blueberry fruit qua season in Pacific Northwest g
Stockwell, Hardigan	USDA-Northwest Center for Small Fruit Research	$98,000	09/2022-09/2024	5%	Assessing the role of Gnomo other fungal cane blight patho Collapse
Hoashi-Erhardt, **Hardigan**, Zasada, Dossett	USDA-Northwest Center for Small Fruit Research	$135,000	09/2023-09/2025	10%	Genomic Prediction for Quan Root Lesion Nematode in Ra
Hardigan, Strik	Oregon Raspberry Blackberry Commission	$36,940	09/2023-09/2024	10%	Cooperative Caneberry Breed Cultivar and Selection Evalua
Pending:					

Appendix II: Tables

Table Ry-FL 1. Fruit size and yield of floricane-fruiting red raspberry genotypes tested in OSU-NWREC 2020 trial planting, harvested from 2022-23. Yield measurements are based on twice-weekly machine harvests performed using an Oxbo 7450 Harvester.

	Berry Size (g)	Yield (tons·a-1)		
Annual Mean [a]				
2022	1.91	2.83		
2023	3.09	4.84		
Genotype	2022-23	2022	2023	2022-23
Replicated [z]				
WSU 2087	2.55 bc	4.11	4.59	4.35 a
WSU 2472	2.95 a	2.45	6.16	4.30 ab
WSU 2069	2.35 cd	3.32	5.23	4.28 ab
WSU 2425	2.25 d	2.61	5.28	3.95 ab
ORUS 5195-2	2.13 d	2.67	5.08	3.87 ab
ORUS 4600-1	2.60 b	2.78	4.60	3.69 ab
Meeker	**2.27 d**	**2.39**	**4.09**	**3.24 ab**
WSU 2481	2.88 a	2.33	3.72	3.03 b
Nonreplicated				
ORUS 5199-1	2.85	2.30	5.22	3.76
ORUS 5205-1	2.80	2.18	5.13	3.65
ORUS 4371-4	2.85	3.19	3.17	3.18
[*]*ORUS 4607-2*	2.45	4.11	1.53	2.82
ORUS 5198-3	2.70	2.04	3.16	2.60
ORUS 5198-1	2.40	1.97	1.89	1.93
WSU 2577	2.40	2.19	1.65	1.92

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

Table Ry-FL 2. Fruit size and yield of floricane-fruiting red raspberry genotypes tested in OSU-NWREC 2021 trial planting, harvested from 2023. Yield measurements are based on twice-weekly machine harvests performed using an Oxbo 7450 Harvester.

	Berry Size (g)	Yield (tons·a-1)
Annual Mean [a]		
2023	2.93	4.10
Genotype	2023	2023
Replicated [z]		
Meeker	**2.47 c**	**4.89 a**
ORUS 4843-2	3.67 a	4.86 a
WSU 2001	3.23 b	4.34 a
ORUS 4462-2	2.80 c	3.93 a
ORUS 4692-4	2.00 d	3.76 a
ORUS 4373-1	3.40 ab	2.85 a
Nonreplicated		
ORUS 5310-1	3.90	7.23
ORUS 5309-1	3.40	6.34
ORUS 5309-2	3.30	6.06
ORUS 5329-1	4.30	5.61
ORUS 5323-2	3.40	5.47
ORUS 5315-1	4.70	5.34
[*]ORUS 4600-1	2.50	5.23
ORUS 5320-3	4.00	5.23
ORUS 5322-2	2.60	5.19
ORUS 5328-1	3.50	5.10
ORUS 5328-3	3.30	4.98
ORUS 5309-3	2.60	4.97
ORUS 4692-1	3.50	4.92
ORUS 5324-2	3.30	4.84
ORUS 5323-1	2.30	4.84
ORUS 5315-3	2.90	4.76
ORUS 5318-2	2.60	4.69
ORUS 5320-2	2.60	4.40
ORUS 5317-3	2.70	4.40
ORUS 5328-2	3.70	4.40
ORUS 5319-3	2.00	4.34
ORUS 5325-2	3.60	4.25

ORUS 5321-1	2.40	4.13
ORUS 4371-4	3.60	4.06
ORUS 5317-2	2.90	4.05
ORUS 5318-5	2.60	4.04
ORUS 5315-5	3.30	3.96
ORUS 5322-1	2.20	3.96
ORUS 5316-1	2.30	3.93
ORUS 5325-1	3.00	3.74
ORUS 5319-4	2.00	3.69
ORUS 5321-2	2.60	3.63
ORUS 5315-2	3.60	3.62
ORUS 5313-1	3.10	3.53
ORUS 5318-1	2.90	3.46
ORUS 5315-4	2.40	3.39
ORUS 5310-3	3.80	3.17
ORUS 5319-2	2.30	3.01
ORUS 5318-3	3.00	2.96
ORUS 5321-3	2.10	2.92
ORUS 5319-1	2.40	2.88
ORUS 4698-3	2.30	2.84
ORUS 5327-1	3.00	2.62
ORUS 5324-1	2.70	2.21
ORUS 5323-3	1.80	2.02
ORUS 5311-1	2.20	1.88
ORUS 4607-2	2.30	1.23
ORUS 5312-1	2.10	1.12
ORUS 5324-3	2.30	0.99

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

Table Ry-Season. Ripening season of all red raspberry genotypes tested in recent OSU-NWREC trial plantings (averaged across trial plots and years).

		Ripening Date		
Cultivar	Type [y]	5%	50%	95%
ORUS 4837-2	FL	6/13	6/23	7/7
ORUS 4837-1	FL	6/13	6/25	7/10
WSU 2511	FL	6/20	6/25	7/11
[*]ORUS 4089-2	FL	6/25	6/25	6/25
ORUS 4692-1	FL	6/18	6/26	7/9
Wakefield	**FL**	**6/23**	**6/26**	**7/14**
WSU 2130	FL	6/20	6/26	7/10
ORUS 4846-1	FL	6/20	6/26	7/12
ORUS 4961-1	FL	6/19	6/27	7/13
ORUS 4698-3	FL	6/22	6/27	7/11
WSU 2506	FL	6/22	6/27	7/13
ORUS 5108-3	FL	6/30	6/27	7/23
Georgia	**FL**	**6/18**	**6/28**	**7/14**
ORUS 4692-2	FL	6/20	6/28	7/10
WSU 2205	FL	6/20	6/28	7/10
WSU 2421	FL	6/20	6/28	7/15
ORUS 4641-3	FL	6/21	6/28	7/13
WSU 2505	FL	6/15	6/28	7/13
WSU 2298	FL	6/19	6/28	7/13
Cascade Harvest	**FL**	**6/22**	**6/29**	**7/13**
ORUS 4465-2	FL	6/22	6/29	7/13
ORUS 5100-1	FL	6/22	6/29	7/13
Wakehaven	**FL**	**6/22**	**6/29**	**7/13**
WSU 2268	FL	6/22	6/29	7/13
WSU 2277	FL	6/22	6/29	7/13
WSU 2605	FL	6/18	6/30	7/15
WSU 2191	FL	6/20	6/30	7/12
WSU 2472	FL	6/22	6/30	7/11
ORUS 5309-1	FL	6/22	6/30	7/14
ORUS 5315-3	FL	6/22	6/30	7/14
ORUS 5315-4	FL	6/22	6/30	7/14
ORUS 5317-2	FL	6/22	6/30	7/14
ORUS 5317-3	FL	6/22	6/30	7/14
ORUS 5318-5	FL	6/22	6/30	7/14

WSU 2069	FL	6/22	6/30	7/14
WSU 2425	FL	6/22	6/30	7/14
ORUS 4713-1	FL	6/23	6/30	7/12
WSU 1914	FL	6/23	6/30	7/14
ORUS 4843-1	FL	6/25	6/30	7/17
WSU 2377	FL	6/19	6/30	7/13
WSU 2437	FL	6/22	6/30	7/13
WSU 2299	FL	6/22	7/1	7/14
WSU 2123	FL	6/21	7/1	7/15
ORUS 5099-1	FL	6/21	7/1	7/19
ORUS 4713-2	FL	6/23	7/1	7/13
WSU 2202	FL	6/23	7/1	7/15
WSU 2366	FL	6/23	7/1	7/15
ORUS 4603-2	FL	6/20	7/2	7/12
ORUS 4600-2	FL	6/25	7/2	7/16
ORUS 4965-3	FL	6/27	7/2	7/11
WSU 2087	FL	6/22	7/2	7/12
**ORUS 4715-2*	FL	6/27	7/2	7/18
ORUS 4690-1	FL	6/23	7/3	7/13
ORUS 4707-1	FL	6/23	7/3	7/13
ORUS 4851-2	FL	6/23	7/3	7/15
WSU 2188	FL	6/23	7/3	7/15
**ORUS 4974-1*	FL	6/25	7/3	7/15
ORUS 4692-4	FL	6/24	7/3	7/15
ORUS 4851-1	FL	6/23	7/3	7/15
WSU 2195	FL	6/23	7/3	7/15
ORUS 5104-2	FL	6/25	7/3	7/17
ORUS 5106-3	FL	6/28	7/3	7/17
**ORUS 4371-4*	FL	6/25	7/3	7/15
**ORUS 4600-1*	FL	6/25	7/3	7/16
WSU 2088	FL	6/22	7/3	7/14
ORUS 4640-1	FL	6/19	7/4	7/13
ORUS 4965-1	FL	6/22	7/4	7/11
ORUS 1154R-3	FL	6/24	7/4	7/18
ORUS 3959-1	FL	6/24	7/4	7/18
ORUS 4715-1	FL	6/24	7/4	7/18
ORUS 4607-2	FL	6/24	7/4	7/15
ORUS 4600-3	FL	6/21	7/4	7/14
Meeker	**FL**	**6/24**	**7/4**	**7/15**

ORUS 5205-1	FL	6/22	7/5	7/14
ORUS 5320-3	FL	6/22	7/5	7/14
ORUS 5322-1	FL	6/22	7/5	7/14
ORUS 5323-2	FL	6/22	7/5	7/14
ORUS 5329-1	FL	6/22	7/5	7/14
ORUS 4843-2	FL	6/22	7/5	7/17
ORUS 5322-2	FL	6/22	7/5	7/17
ORUS 5325-1	FL	6/22	7/5	7/17
WSU 2234	FL	6/22	7/5	7/14
ORUS 4707-2	FL	6/23	7/5	7/13
WSU 2162	FL	6/23	7/5	7/13
WSU 2481	FL	6/24	7/5	7/18
ORUS 4603-1	FL	6/25	7/5	7/16
AAC Eden	**FL**	**6/25**	**7/5**	**7/19**
ORUS 5198-3	FL	6/27	7/5	7/14
ORUS 5315-2	FL	6/27	7/5	7/14
ORUS 5319-4	FL	6/27	7/5	7/14
ORUS 5328-1	FL	6/27	7/5	7/14
ORUS 5328-3	FL	6/27	7/5	7/14
ORUS 5195-2	FL	6/27	7/5	7/17
ORUS 5199-1	FL	6/27	7/5	7/17
ORUS 5309-2	FL	6/27	7/5	7/17
ORUS 5310-1	FL	6/27	7/5	7/17
ORUS 5318-3	FL	6/27	7/5	7/17
ORUS 5320-2	FL	6/27	7/5	7/17
ORUS 5325-2	FL	6/27	7/5	7/17
ORUS 5321-2	FL	6/30	7/5	7/14
ORUS 4961-5	FL	6/15	7/5	7/13
ORUS 4961-3	FL	6/22	7/5	7/13
ORUS 4971-2	FL	6/22	7/5	7/13
WSU 2348	FL	6/22	7/5	7/13
WSU 2357	FL	6/22	7/5	7/13
WSU 2376	FL	6/22	7/5	7/13
WSU 2432	FL	6/22	7/5	7/13
WSU 2442	FL	6/22	7/5	7/13
WSU 2510	FL	6/22	7/5	7/13
ORUS 4971-1	FL	6/23	7/5	7/13
ORUS 4971-3	FL	6/23	7/5	7/13
ORUS 4972-1	FL	6/23	7/5	7/13

ORUS 4978-1	FL	6/23	7/5	7/13
ORUS 4978-2	FL	6/23	7/5	7/13
ORUS 4978-3	FL	6/23	7/5	7/13
WSU 2278	FL	6/23	7/5	7/13
WSU 2372	FL	6/23	7/5	7/13
ORUS 4975-1	FL	6/25	7/5	7/13
ORUS 5105-1	FL	6/28	7/5	7/19
ORUS 5106-1	FL	6/28	7/5	7/19
ORUS 5107-1	FL	6/25	7/6	7/13
ORUS 4373-1	FL	6/24	7/7	7/17
WSU 2516	FL	6/25	7/7	7/19
ORUS 4462-2	FL	6/27	7/7	7/17
ORUS 5315-1	FL	6/27	7/7	7/17
ORUS 5315-5	FL	6/27	7/7	7/17
ORUS 5318-2	FL	6/27	7/7	7/17
ORUS 5319-1	FL	6/27	7/7	7/17
ORUS 5319-3	FL	6/27	7/7	7/17
ORUS 5321-1	FL	6/27	7/7	7/17
ORUS 5321-3	FL	6/27	7/7	7/17
ORUS 5311-1	FL	6/30	7/7	7/14
ORUS 5309-3	FL	6/30	7/7	7/17
ORUS 5313-1	FL	6/30	7/7	7/17
ORUS 5323-1	FL	6/30	7/7	7/17
WSU 2385	FL	6/22	7/7	7/16
ORUS 4690-3	FL	6/24	7/8	7/18
ORUS 4694-1	FL	6/24	7/8	7/18
ORUS 4715-3	FL	6/24	7/8	7/18
ORUS 5106-2	FL	6/22	7/9	7/13
ORUS 4845-2	FL	6/22	7/9	7/13
ORUS 5094-2	FL	6/22	7/9	7/13
ORUS 5104-4	FL	6/22	7/9	7/13
ORUS 4845-3	FL	6/25	7/9	7/13
ORUS 5105-2	FL	6/25	7/9	7/13
ORUS 4463-1	FL	6/25	7/9	7/13
ORUS 5319-2	FL	6/27	7/11	7/17
ORUS 5324-1	FL	6/27	7/11	7/17
ORUS 5324-2	FL	6/27	7/11	7/17
WSU 2001	FL	6/27	7/11	7/20

ORUS 5310-3	FL	6/30	7/11	7/14
ORUS 5318-1	FL	6/30	7/11	7/17
ORUS 5323-3	FL	6/30	7/11	7/17
ORUS 5328-2	FL	6/30	7/11	7/20
ORUS 5198-1	FL	7/5	7/11	7/17
ORUS 5316-1	FL	7/5	7/11	7/17
ORUS 5327-1	FL	7/5	7/11	7/17
WSU 2577	FL	7/5	7/11	7/17
ORUS 5102-2	FL	6/28	7/12	7/19
ORUS 5094-1	FL	6/30	7/12	7/19
ORUS 5312-1	FL	7/5	7/14	7/14
ORUS 5324-3	FL	7/5	7/14	7/17
ORUS 4840-1	FL	6/28	7/15	7/18
ORUS 4988-2	PF	7/17	7/24	7/24
ORUS 4988-1	PF	7/17	7/24	8/14
ORUS 4988-3	PF	7/17	8/7	8/14
Amaranta	**PF**	**7/17**	**8/7**	**8/28**
ORUS 4864-1	PF	7/24	8/7	8/21
ORUS 5218-1	PF	7/27	8/7	8/24
ORUS 5250-1	PF	7/27	8/7	8/31
**ORUS 4291-1*	PF	7/30	8/7	8/25
ORUS 5005-3	PF	7/31	8/7	8/28
ORUS 4981-2	PF	7/31	8/7	9/4
Polka	**PF**	**7/28**	**8/10**	**8/26**
ORUS 4725-1	PF	7/27	8/10	8/24
ORUS 5211-1	PF	7/27	8/10	8/28
ORUS 5005-1	PF	8/1	8/13	8/29
BP-1	**PF**	**7/24**	**8/14**	**9/4**
ORUS 4858-3	PF	7/31	8/14	8/28
ORUS 4873-1	PF	7/31	8/14	8/28
ORUS 4872-1	PF	7/31	8/14	9/18
ORUS 4988-5	PF	8/3	8/14	8/27
ORUS 4988-4	PF	8/7	8/14	8/21
Lagorai Plus	**PF**	**8/7**	**8/14**	**8/28**
ORUS 5248-3	PF	8/14	8/14	9/7
ORUS 5005-2	PF	8/1	8/15	9/1
ORUS 5201-2	PF	8/3	8/17	9/7
ORUS 4289-4	PF	8/3	8/17	8/21

ORUS 5209-2	PF	8/3	8/17	8/28
ORUS 5248-1	PF	8/3	8/17	8/31
ORUS 4858-1	PF	8/4	8/18	8/28
Imara	**PF**	**8/6**	**8/20**	**9/11**
ORUS 5109-2	PF	8/9	8/20	8/25
**ORUS 5209-1*	PF	8/3	8/21	9/7
ORUS 4494-3	PF	8/7	8/21	9/11
ORUS 5004-2	PF	8/14	8/21	8/21
ORUS 4289-3	PF	8/14	8/21	9/4
ORUS 4856-1	PF	8/14	8/21	9/11
ORUS 5467-1	PF	8/8	8/22	9/6
**ORUS 4487-1*	PF	8/3	8/22	9/9
ORUS 5465-1	PF	7/29	8/23	9/9
ORUS 5118-1	PF	8/6	8/23	9/6
ORUS 5243-1	PF	8/11	8/23	8/30
ORUS 5345-2	PF	8/3	8/24	8/31
ORUS 5332-1	PF	8/3	8/24	9/7
ORUS 4858-2	PF	8/5	8/24	9/10
Kweli	**PF**	**8/6**	**8/24**	**9/11**
ORUS 4874-1	PF	8/10	8/24	9/7
ORUS 5220-1	PF	8/14	8/24	9/7
ORUS 5114-1	PF	8/9	8/25	9/6
ORUS 5114-2	PF	8/16	8/25	8/30
Heritage	**PF**	**8/16**	**8/25**	**9/7**
ORUS 4985-1	PF	8/19	8/26	9/6
ORUS 5467-2	PF	8/2	8/26	9/9
ORUS 5345-1	PF	8/12	8/26	9/16
Kokanee	**PF**	**8/7**	**8/26**	**9/12**
Vintage	**PF**	**8/10**	**8/27**	**9/10**
ORUS 4857-1	PF	8/14	8/28	9/4
ORUS 5227-2	PF	8/14	8/28	9/7
ORUS 5248-2	PF	8/14	8/28	9/7
ORUS 5227-3	PF	8/14	8/28	9/11
Crimson Treasure	**PF**	**8/1**	**8/29**	**9/19**
Finnberry	**PF**	**8/18**	**8/29**	**9/14**
ORUS 5347-1	PF	8/16	8/30	9/13
ORUS 4990-1	PF	8/14	8/31	9/22
Kwanza	**PF**	**8/17**	**8/31**	**9/15**

ORUS 5243-2	PF	8/23	9/1	9/15
ORUS 4981-1	PF	8/29	9/6	9/19
ORUS 5243-3	PF	8/18	9/6	9/15
ORUS 5332-2	PF	8/23	9/6	9/20
ORUS 4722-2	PF	8/25	9/9	9/21
ORUS 5465-2	PF	8/26	9/9	9/16
ORUS 4989-1	PF	9/3	9/14	9/22
ORUS 5004-3	PF	9/3	9/14	9/22
ORUS 4722-1	PF	8/28	9/18	9/26
ORUS 4861-1	PF	9/18	9/18	9/26
ORUS 5465-3	PF	9/12	9/19	9/19
ORUS 5344-1	PF	9/21	9/21	9/21
ORUS 5004-5	PF	9/18	9/26	9/26

[y] FL=Floricane-fruiting; PF=Primocane-fruiting.
[*]Nursery list – available at nurseries for grower trial by request.

Project Title: Cooperative raspberry testing and cultivar development program.

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

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

Year Initiated __2013___ Current Year 2024-2025 Terminating Year _Continuing__

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

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

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

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

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

The program is focused on developing cultivars that are able to replace or complement current industry cultivars such as 'Meeker' or 'Wakefield' to support the long-term viability of the regional industry. Each year we produce new experimental selections and evaluate their performance 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 assess thawed IQF quality in collaboration with OSU Food Science.

Justification and Background: (<400 words)

The PNW is one of the most important berry production regions in the world. This success is due to a combination of an outstanding growing environment, top-notch growers, and a 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.

Relationship to WRRC Research Priorities:

The objectives tie directly to the following priorities:

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

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

- Fruit rot including pre harvest, post-harvest, and/or shelf life (2)
- Foliar & Cane diseases – i.e. spur blight, yellow rust, cane blight, powdery mildew (1)
- Viruses/crumbly fruit, pollination (3)

Objectives:

The following objectives are addressed simulanteously each year:

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

Procedures: (<400 words)

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

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

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

Selections that 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 WRRC machine harvest trials at Honcoop Farms and other grower trials near Lynden, WA.

Anticipated Benefits and Information Transfer: (<100 words)

The breeding program will develop raspberry cultivars and advanced selections with better performance, 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: $ 6,000

	2021	2023	2024
Salaries[1/]	$9,000	$6,000	$7,000
Time-Slip	$	$	$
Operations (goods & services)	$1,000	$	$
Travel	$	$	$
Meetings	$	$	$
Other[2/]	$5,000	$	$
Equipment	$	$	$
Benefits	$	$	$
Total	**$15,000**	**$**6,000	**$7,000**

Budget Justification

We are requesting a $1,000 increase from FY23 due to the increasing cost of supporting federal and Oregon State University employees.

[1/]Student labor (1 student GS-2, 4 summer months = $10,800).

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

ENTOMOLOGY

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
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Cooperators: Tom Walters, Walters Ag Research

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

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

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 $17,955.

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 in 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.

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 propose to initiate a trial in 2024 on raspberries only using products registered on raspberries (some products previously screened were not registered but now are registered on raspberries). We propose to start early in the season and use a larger number of products than in 2023.

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.

Objective 3. Determine how widespread Acramite resistance in TSSM is in the Washington red raspberry industry.

Objective 4. 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.

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 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. Growers are interested in obtaining information about Nealta, a BASF product. BASF has expressed interest in allowing Nealta to be registered on raspberry via the IR-4 Project if sufficient positive efficacy data and low/non-phytotoxicity data can be demonstrated. It is our hope that based on one to two years of efficacy data that BASF will allow this product to enter the IR-4 registration process. Applications would follow labeled use patterns or proposed use patterns.

Resistance Data. We plan to collect mites after applications of Acramite during the 2024 growing seasons from multiple fields. These mites will be assayed for the genes associated with Acramite resistance.

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, prebloom 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.

All products in both trials we plan to screen are registered on raspberries with the exception of Nealta. We hope that this will allow an earlier application timing for miticides.

Anticipated Benefits and Information Transfer:

Our goal is to develop biological information that will allow improved control of mites 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:	**2024**	**2025**
Salaries	3,500	3,500
Operations	990	1,000
Travel	650	640
Contract Research*	6,200	6,200
Benefits	1,155	1,155
Total	**$12,495**	**$12,495**

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

2024 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

Project Title: Thrips Identification and Biology in Red Raspberries

PI: Louis Nottingham
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Co-PI:
Organization:
Title:
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Email:
Address:
City/State/Zip:

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

Total Project Request: **Year 1 $14,095** **Year 2 $14,095** **Year 3 $**

Other funding sources: *(If no other funding sources are anticipated, type in "None" and delete agency name, amt. request and notes)*
Agency Name: 1. WCIPM; 2. USDA NIFA SCRI
Amt. Requested: 1. WCIPM ($13,527) 2. USDA NIFA SCRI (Preproposal phase, no amount requested yet)
Notes:

Description:
Washington State is the largest producer of processed red raspberries in the United States, primarily focused in Whatcom County. Thrips have become an increasing issue to the industry, with 2023 having particularly heavy pressure. Thrips feed on leaves, flowers, and ripe fruit, and have the potential to spread plant viruses. In raspberries there is little information about which thrips species are responsible for damage, their biology, or their economic injury levels. This project will gather important biological information about thrips and build better scouting protocols and management programs. **Objectives**: 1) Identify thrips species, map their seasonal development on different part of the raspberry plants, and test for viruses. 2) Determine if wild plants, such as weeds or wild blackberry are sources of thrips. 3) Communicate findings with industry members through monthly in-season meetings and contribute to results to recommendation guides (PNW Handbooks, WSU Decision Aid System, and WSU Crop Protection Guides). **Expected Outcomes:** Improved understanding of the seasonal phenology of thrips species in raspberries and wild plants, which will inform scouting and management options.

Justification and Background:
Washington State is the leading exporter of raspberries, a lucrative high value crop. Washington raspberries are attacked by a plethora of insects, including spotted wing drosophila (SWD), multiple lepidopterans, spider mites, and thrips. Historically, thrips have been a lower concern to

growers; however, in recent years pressure has risen. This could be the result of insecticide resistance, for which the most common pest species, *F. occidentalis* (western flower thrips), is known (Gao et al. 2012). In addition to feeding injury, thrips are known to transmit plant viruses that affect raspberries and blackberries, like tospoviruses, which could be an even greater problem for the raspberry industry. Industry stakeholders have expressed serious concerns about rising thrips pressure and lack of knowledge on this pest. **At the 2023 WRRC Research Review, industry stakeholders stated that improved information on thrips in raspberries was a top need.**

While *Frankliniella* is a known genus that occurs in raspberries, other species maybe part of this complex, and their potential to damage and transmit viruses is unknown. Also, most thrips species can feed and develop on multiple plant species, so wild blackberry and weeds may serve as refugia for both thrips and viruses. Finally, there are many predatory thrips species that could be providing unrealized biological control of pests. For example, sixspotted thrips, *Scolothrips sexmaculatus*, are native the northwest and considered one of the best predators of spider mites in PNW tree nuts (Haviland 2017). Making sprays due to misidentifying predators as pests can lead to much worse pest infestations.

In order to help growers and crop advisors make the best management decisions regarding thrips, it is critical that they first understand which species are present and their seasonal biology. Growers should also know if thrips are developing in common wild plants like weeds and wild blackberry, so they can either remove these alternative host plants and/or use them for predicting infestations. Finally, information in current recommendation tools like the PNW Handbooks, is lacking details (and pictures) on thrips biology and management. We will update current resources and contribute information to new WSU Extension resources including a small fruit crop protection guide and the Decision Aid System.

Relationship to WRRC Research Priority(s):

- Thrips – understand the lifecycle, and control strategies – new
- Viruses/crumbly fruit, pollination

Objectives:

(All objectives will be repeated in 2025 if funding is renewed)

1. Identify thrips species, map their seasonal development on different part of the raspberry plants, and test for viruses (April – December 2024).
2. Determine if wild plants are harboring thrips, such as wild blackberry and weeds (April – October 2024).
3. Communicate results through frequent meetings with industry members and contributions to Extension publications (PNW Handbooks, WSU Decision Aid System, and WSU Crop Protection Guides) (February 2024 – November 2024).

Procedures:

1. **Identify thrips species, map their seasonal development on different part of the raspberry plants, and test for viruses (April – December 2024).**
   We will establish commercial sampling fields with industry collaborators that have had high thrips infestations in the past. Four raspberry fields will be sampled for thrips in Whatcom County, and two organic raspberry fields in Skagit County. Thrips will be sampled on leaves,

flowers, and fruit, and injury to each will be recorded. Thrips will be returned to the lab and slide mounted for identification to species. We will store a subsample of thrips and plant parts in a -80º C freezer to be tested for viruses.

2. **Determine if wild plants, such as wild blackberry and weeds, harbor thrips (April – September 2024).**
   Nearest patches of Himalayan blackberry or evergreen blackberry to raspberry field sites will be identified and scouted for thrips using the same methods described in Obj 1. We will ID thrips to species and save a subsample for virus testing, as in Obj.1. Within and adjacent to raspberry plots, we will visually scout for thrips in patches of weeds. Weed species and presence/absence of thrips will be recorded.

3. **Communicate results through frequent meetings with industry members and contributions to Extension publications (PNW Handbooks, WSU Decision Aid System, and WSU Crop Protection Guides) (January 2024 – December 2024).**
   Monthly meetings with industry members will be held in Whatcom County to discuss commercial agronomic and pest management activities, and to share research results. We will work with the growers and crop advisors to establish thrips sampling plots. After all data are collected and summarized for the season, we will begin writing a WSU Extension Factsheet that integrates our project results, and provides scouting and management recommendations (pear psylla example). We will contribute our findings from this project to the existing PNW Handbooks, and to new small fruit recommendation guides specific to Washington, including the Decision Aid System (website for phenology models) and WSU Crop Protection Guides (digital and physical booklets with recommendations for insecticides and agronomic practices – tree fruit example).

Anticipated Benefits and Information Transfer

- Provide growers and crop advisors with practical information about thrips such as their life cycle, potential for injury, and strategies for scouting and management.
- Growers and crop advisors will know if they should scout or remove non-crop plants like weeds and blackberries due to harboring pest thrips.
- Industry will better understand potential risks of viruses transmitted by thrips.
- Information transfer described in Obj. 3. We will directly communicate with industry decision makers throughout the season at monthly meetings. We will also create online resources such as an open access printable Extension factsheet, PNW Handbooks, and new WSU crop recommendation guides.

References:

Crop Protection Guide for Tree Fruits in Washington. 2023. https://cpg.treefruit.wsu.edu/

Gao, Y., Z. Lei, and S. R. Reitz. 2012. Western flower thrips resistance to insecticides: detection, mechanisms and management strategies. Pest Manag Sci 68: 1111-1121.

Haviland, D. Year. Published. Evaluation of six-spotted thrips, Scolothrips sexmaculatus, for biological control of spider mites in California almonds, pp. 290-291. *In*, Proceedings of the 5th International Symposium on Biological Control of Arthropods, Langkawi, Malaysia, September 11-15, 2017, 2017. CABI Wallingford UK.

Nottingham, L. B., R. J. Orpet, R. Hilton, and S. T. DuPont. 2023. Pear Psylla Integrated Pest Management. Washington State University Extension Publications. Pullman, WA. FS376E.

https://s3.us-west-2.amazonaws.com/treefruit.wsu.edu/wp-content/uploads/2023/07/20132103/FS376E_Pear-Psylla-Integrated-Pest-Management-f.pdf
Pacific Northwest Pest Management Handbooks. 2024. https://pnwhandbooks.org/
WSU Decision Aide System. 2024. https://decisionaid.systems/

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

	2024	**2025**
Salaries[1/]	$9,020	$9,020
Time-Slip	$	$
Operations (goods & services) [3/]	$200	$200
Travel[2/]	$1,625	$1,625
Meetings	$	$
Other	$	$
Equipment	$	$
Benefits[4/]	$3,250	$3,250
Total	**$14,095**	**$14,095**

Budget Justification

[1/]Assistant Professor @ 3%FTE ($3,485) + Research Assistant @ 10% FTE ($5,535)

[2/]Provide brief justification for travel requested. Travel to Whatcom County field sites from Mount Vernon NWREC. 100 miles/week x 25 weeks =2500 miles. 20 mpg @ $5/gal = $625. $40/week motor pool fee x 25 weeks = $1000.

[4/]Assistant Professor @ 27.8% benefits ($968) + Research Assistant @ 41.2% benefits ($2,282)

Washington Commission on Integrated Pest Management, 2023 Progress Report

Developing an Insect IPM Program for the Washington Raspberry Industry | #23PN021, Raspberry

Henry Bierlink and Louis Nottingham (WSU)

Project Description. This project developed and examined IPM programs in WA red raspberries compared with organic and standard conventional programs.

Progress. In March 2023, a technical working group of blueberry and raspberry industry crop advisors (most work in both crops) was established. Beginning in April, weekly (later in the season, biweekly) meetings were held with this group to better understand standard commercial pest management practices, develop IPM programs, and establish scouting locations with conventional, organic, and IPM blocks. Twelve blueberry and nine raspberry sites were established for sampling, with equal numbers from each management treatment. Sites were sampled bi-weekly from April through September, and spray records were collected. Data have been entered and most are in preliminary stages of analysis and summarization. Insect density comparisons are complete and economic comparisons are underway.

Results. IPM programs, in their current state showed marginal differences from standard conventional programs. This is expected, give the low requirements given to these plots (in most cases, IPM programs substituted one pyrethroid spray for a selective material, such as Spear T). Organic plots had higher abundances of SWD and thrips, but not spider mites, compared with standard and IPM plots. Organic also had greater abundances of natural enemies that standard and IPM plots, while IPM plots were not different than the standard.

Conclusions: This year suggests conventional programs are currently more effective at controlling pests than organic and IPM programs, except for spider mites which were not different. IPM plots did not provide a noticeable advantage or disadvantage compared to the standard, in terms of insects. Despite this, conventional programs use numerous broad-spectrum sprays, which runs the risk of future control failures due to resistance development and/or losses of registrations. It is important that IPM program are refined to provide improvements to standard conventional management, otherwise it will be difficult to encourage integrated programs, which are more resilient to changes and less harmful to the environment and humans.

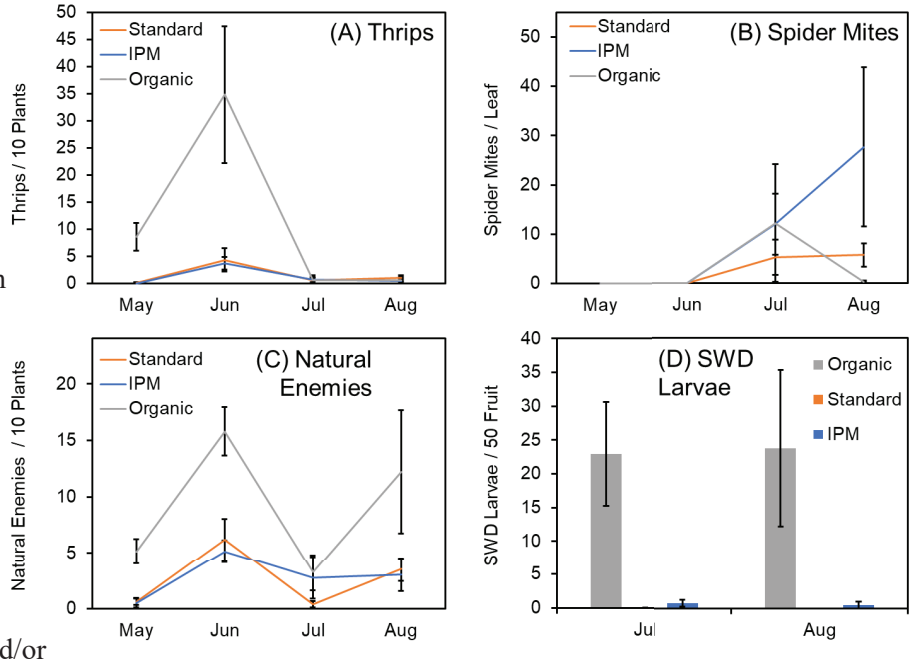

Fig. Field insect densities in raspberry plots under conventional, IPM or organic management, averaged by month (A-C). Thrips and nature enemies were collected via reverse leaf blower (D-vac), spider mites were sampled from collected leaves via brushing. SWD larvae per 50 fruits (raspberry and blueberry combined) harvested in July and August (D).

2024 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

New Project Proposal (Yes/No): Yes **Proposed Duration** (1, 2, or 3 years): 3 years

Project Title: Insect Pest Management in Red Raspberry Crops utilizing UAV Technology

PI: Kurt Beckley
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Co-PI:
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Cooperators:

Year Initiated: 2024 **Current Year**: 2023 **Terminating Year**: 2027

Total Project Request: **Year 1 $** 25,000 **Year 2 $** 25,000 **Year 3 $** 25,000

Other Funding Sources: *(If no other funding sources are anticipated, type in "None".)*

Agency Name: None

Amount Requested/Awarded: *(requested) $75,000*

Notes:

Description: The objective of this proposal is to develop and implement a comprehensive Insect Pest Management program for Red Raspberry crops using Uncrewed Aerial Vehicles (UAVs) integrated with advanced technology to enhance the identification of pest infestations, set threshold levels, determine optimal application timing, and specifically target the Mites, Cutworms, Leafrollers, and Thrips, all major pests of Red Raspberry crops. UAVs provide for a large scale scanning and monitoring capability as well as digital images of the plots that can be analyzed for pest identification on a comprehensive basis and then ground proofed over specific locations vs. current methodologies. These pests can then be controlled through UAV application methods which provide excellent efficacy.

Justification and Background:

Issue being addressed: Red Raspberries are a vital crop in the Pacific Northwest with a significant global economic impact. However, it is highly susceptible to various pests, including the destructive Mites, Cutworms, Leafrollers, and Thrips. Effective pest management is crucial to ensure Red Raspberry crop health and maximize yields. The integration of UAV technology with precise pest management strategies offers a promising solution.

Why address this issue: Controlling the Mites, Cutworms, Leafrollers, and Thrips in Red Raspberry Crops in Washington State is of paramount importance for several compelling reasons: Economic Impact, Crop Yield Protection, Quality Assurance, Conservation of Natural Resources, Crop Rotation and Resistance Management, Sustainable Agricultural Practices, and Food Security.

Relation to other projects: The Insect Pest Management project for Red Raspberry Crops using UAV technology in Washington State relates to various agricultural and sustainability initiatives in the region. It provides a technological and methodological framework that can be adapted and integrated into existing and future projects aimed at improving crop health, sustainability, and overall agricultural practices in Washington State and the Pacific Northwest. The sharing of knowledge and resources can lead to more effective and eco-friendly agricultural solutions that benefit the entire region.

Project Duration: Three years, Crop years 2024, 2025, and 2026

Components of the Pest Management Plan:
Identification:

• Utilize UAVs equipped with advanced sensors, such as hyperspectral cameras and thermal imaging, to identify early signs of pest infestations.
• Conduct regular UAV scouting flights over Red Raspberry fields to monitor the presence and distribution of Mites, Cutworms, Leafrollers, and Thrips.
• Implement machine learning algorithms for automated pest identification and mapping.

Thresholds:
• Establish pest density thresholds through data analysis to determine when intervention is necessary.
• The threshold levels will be data-driven and consider factors such as the crop growth stage, Mites, Cutworms, Leafrollers, and Thrips populations, and environmental conditions.
• Once the threshold is reached, it will trigger the initiation of control measures.

Application Timing:
• Employ UAVs for precise timing of pest control measures.
• Utilize real-time data from the UAVs, including weather conditions, crop phenology, and pest life cycles, to optimize the timing of pesticide applications.
• Implement Integrated Pest Management (IPM) principles to prioritize eco-friendly and sustainable control methods.

Target: Mites, Cutworms, Leafrollers, and Thrips Management:
• Develop a specific control strategy for the Mites, Cutworms, Leafrollers, and Thrips, which includes:
• Monitoring pest patterns using UAVs.
• Data analysis to predict peak periods.
• Implementation of targeted pesticide applications during peak activity.
• Investigation of alternative, non-chemical control methods, such as biological control agents which can be applied via UAVs.

Implementation Plan:

Technology Acquisition:
• Procure appropriate sensors and imaging technology and deploy appropriate UAVs.
• Develop or acquire software for data analysis, pest identification, and predictive modeling utilizing AI.
Field Trials:
• Conduct field trials in collaboration with Red Raspberry growers to test the effectiveness of UAV-based IPM strategies.
• Gather data on pest population dynamics and crop responses.
Data Analysis:
• Analyze collected data to determine threshold levels, optimal application timings, and effectiveness of control measures.
• Refine algorithms for automated pest identification.
Educational Outreach:
• Provide training and resources to Red Raspberry growers on the implementation of UAV-based IPM practices.
• Share research findings and best practices with the agricultural community.

Anticipated Benefits and Information Transfer:
This project will directly benefit producers and the oilseeds industry in Washington State by:

- Improving Red Raspberry crop yields,
- Reducing costs,
- Promoting sustainability, and,
- Enhancing the quality and competitiveness of Red Raspberry products in the market.

The benefits and results of the project can be effectively transferred to others through various means:

- Educational Outreach Programs,
- Extension Services,
- Research Publications,
- Demonstration Farms,
- Online Resources,
- Industry Conferences and Workshops
- Agricultural Education Institutions

By utilizing a combination of these approaches, the benefits and results of the project can be effectively transferred to a wide range of stakeholders, including Red Raspberry producers, growers in other crops, researchers, policymakers, and agricultural industry professionals in Washington State and the broader Pacific Northwest. This knowledge sharing and technology transfer will contribute to the broader adoption of UAV-based pest management and precision agriculture practices in the region.

References:

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Budget Item	2024	2025	2026
Salaries[1]	$	$	$
Time-Slip	$ 7,000	$ 7,000	$ 7,000
Operations (goods & services)	$ 5,000	$ 5,000	$ 5,000
Travel[2]	$ 3,000	$ 5,000	$ 5,000
Meetings	$	$	$
Other	$ 5,000	$ 5,000	$ 5,000
Equipment[3]	$ 5,000	$ 3,000	$ 3,000
Benefits[4]	$	$	$
Total	**$ 25,000**	**$ 25,000**	**$ 25,000**

Budget Justification:

No Salaries are requested for this project

Time Slip funds are for Graduate Research Assistants, interns and hourly

employee pay

Operations funds are requested for supplies related to the project such as:

- Data and specimen collection supplies
- 3rd party specimen analysis services
- General supplies and goods for data collection personnel and Supervisor
- Industry conference presentation materials and supplies
- Marketing materials

Travel funds are for Mileage expenses incurred by all project member. This is calculated by estimating total mileage and multiplying that by current WashiEngton State standard mileage rate of $.655/mile. This amount also includes costs related to attendance at an industry conference for years 2 and 3. Those costs were estimated utilizing the standard lodging and and per diem rates for one person.

Other costs are requested to cover related costs such as :

- Software acquisition and updates
- Liability insurance coverage costs related to time slip employees
- Maintenance and supplies for related UAVs and payloads.

Equipment costs are for specific UAV payloads that have capabilities for pest and disease identification with high quality multi spectral and digital RGB imagery. Payload attachment gimbals , batteries and parts are also part of the initial and ongoing cost

No Benefits are requested for this project.

Proposal: Insect Pest Management for Red Raspberry Crops Utilizing UAV Technology

Objective: The objective of this proposal is to develop and implement a comprehensive Insect Pest Management program for Red Raspberry crops using Uncrewed Aerial Vehicles (UAVs) integrated with advanced technology to enhance the identification of pest infestations, set threshold levels, determine optimal application timing, and specifically target the Mites, Cutworms, Leafrollers, and Thrips, a major pest of Red Raspberry crops. UAVs provide a large-scale scanning and monitoring capability as well as digital images of the plots that can be analyzed for pest identification on a comprehensive basis and then ground proofed over specific locations vs. current methodologies.

Introduction: Red Raspberries are a vital crop with a significant global economic impact. However, it is highly susceptible to various pests, including the destructive Mites, Cutworms, Leafrollers, and Thrips. Effective pest management is crucial to ensure Red Raspberry crop health and maximize yields. The integration of UAV technology with precise pest management strategies offers a promising solution.

Components of the Pest Management Plan:

Identification: • Utilize UAVs equipped with advanced sensors, such as hyperspectral cameras and thermal imaging, to identify early signs of pest infestations. • Conduct regular UAV scouting flights over Red Raspberry fields to monitor the presence and distribution of Mites, Cutworms, Leafrollers, and Thripss. • Implement machine learning algorithms for automated pest identification and mapping.	**Thresholds:** • Establish pest density thresholds through data analysis to determine when intervention is necessary. • The threshold levels will be data-driven and consider factors such as the crop growth stage, Mites, Cutworms, Leafrollers, and Thrips population, and environmental conditions. • Once the threshold is reached, it will trigger the initiation of control measures.
Application Timing: • Employ UAVs for precise timing of pest control measures. • Utilize real-time data from the UAVs, including weather conditions, crop phenology, and pest life cycles, to optimize the timing of pesticide applications. • Implement Integrated Pest Management (IPM) principles to prioritize eco-friendly and sustainable control methods.	**Target: Mites, Cutworms, Leafrollers, and Thrips Management:** • Develop a specific control strategy for the Mites, Cutworms, Leafrollers, and Thrips, which includes: • Monitoring moth flight patterns using UAVs. • Data analysis to predict peak flight periods. • Implementation of targeted pesticide applications during peak moth activity. • Investigation of alternative, non-chemical control methods, such as biological control agents which can be applied via UAVs.

Implementation Plan:

Technology Acquisition: • Procure appropriate sensors and imaging technology and deploy appropriate UAVs. • Develop or acquire software for data analysis, pest identification, and predictive modeling utilizing AI.	**Field Trials:** • Conduct field trials in collaboration with Red Raspberry growers to evaluate the effectiveness of UAV-based pest management strategies. • Gather data on pest population dynamics and crop responses.
Data Analysis: • Analyze collected data to determine threshold levels, optimal application timings, and effectiveness of control measures.	**Educational Outreach:** • Provide training and resources to Red Raspberry growers on the implementation of UAV-based pest management practices.

• Refine algorithms for automated pest identification.	• Share research findings and best practices with the agricultural community.

Controlling the Mites, Cutworms, Leafrollers, and Thrips in Red Raspberry Crops in Washington State is of paramount importance for several compelling reasons:

Economic Impact: Mites, Cutworms, Leafrollers, and Thripss are notorious for their capacity to inflict significant economic damage to Red Raspberry crops. They are voracious feeders, with both larval and adult stages causing harm by feeding on the leaves, buds, and seed pods of Red Raspberry plants. This can result in reduced crop yields and quality, leading to substantial financial losses for Red Raspberry growers in Washington State.	**Crop Yield Protection:** Red Raspberry is an essential oilseed crop, primarily grown for its oil-rich seeds. Mites, Cutworms, Leafrollers, and Thrips infestations can lead to yield reductions, impacting the overall productivity of the Red Raspberry crop. By controlling these pests, growers can safeguard their Red Raspberry yields and maintain profitability.
Quality Assurance: Mites, Cutworms, Leafrollers, and Thripss not only reduce Red Raspberry yields but also diminish the quality of the harvested fruit. Their feeding activities can lead to damaged fruit, reduced Brix content, and increased susceptibility to diseases, affecting the market value of Red Raspberry products. Effective pest control ensures that Red Raspberry meets quality standards for sale and export.	**Conservation of Natural Resources:** Pesticides are commonly used to control Mites, Cutworms, Leafrollers, and Thripss, which can have negative environmental implications. Overuse of pesticides can lead to soil and water contamination, harm non-target organisms, and disrupt the ecosystem. Implementing integrated pest management strategies, as proposed in the previous scenario, can help minimize the reliance on chemical pesticides and reduce the environmental impact.
Resistance Management: In Washington State, Red Raspberry growers often employ insecticide rotation strategies to maintain soil health and reduce the risk of disease and pest buildup. Effective Mites, Cutworms, Leafrollers, and Thrips control is crucial for the success of such rotation practices. Additionally, continuous use of pesticides can lead to pest resistance over time. Careful pest management helps delay resistance development, ensuring that pest control measures remain effective.	**Sustainable Agriculture:** Sustainable agricultural practices are becoming increasingly important in Washington State, as in many other regions. Effective Mites, Cutworms, Leafrollers, and Thrips control supports sustainable agriculture by reducing the need for extensive pesticide applications, conserving natural resources, and promoting environmentally friendly methods, such as biological control.
Food Security: Red Raspberry and Red Raspberry-derived products play a role in the food supply chain. They are used in various food products. By ensuring that Red Raspberry crops are protected from Mites, Cutworms, Leafrollers, and Thrips infestations, the state can contribute to food security by maintaining a stable supply of these essential commodities.	

In summary, controlling the Mites, Cutworms, Leafrollers, and Thrips in Red Raspberry crops in Washington State is essential to protect the economic viability of Red Raspberry farming, ensure high crop yields and quality, reduce environmental impacts, support sustainable agriculture, and enhance food security. Implementing effective pest management strategies is not only a priority for growers but also a crucial step in safeguarding the state's agricultural interests and long-term sustainability.

This project can be closely related to and complementary to various agricultural projects and initiatives within Washington State and the broader Pacific Northwest region. Here is how it relates to other projects in the area:

Integrated Pest Management (IPM) Programs: Many agricultural projects in Washington State and the Pacific Northwest region emphasize IPM practices to control pests and diseases. The Red Raspberry project aligns with the IPM approach by promoting eco-friendly and sustainable pest management practices. It can serve as a model for integrating advanced technology, such as UAVs, into	**Crop Diversification Initiatives:** The Pacific Northwest region has seen an increased interest in diversifying crops to reduce the risk of pests and diseases. This Red Raspberry project can support diversification efforts by offering a model for effective pest management in an alternative crop, further reducing the reliance on a limited set of crops susceptible to specific pests.

existing IPM programs, benefitting a wide range of crops beyond just Red Raspberry.	
Sustainable Agriculture Initiatives: Washington State and the Pacific Northwest have a strong focus on sustainable agriculture. The use of UAVs for precise pest management aligns with sustainable practices by reducing chemical pesticide usage and mitigating environmental impacts. It can contribute to the goals of various sustainability projects in the region.	**Research and Innovation Centers:** Washington State is home to several research institutions and innovation centers dedicated to agricultural research. The Red Raspberry project can establish collaborations with these institutions to leverage their expertise and resources. It can also contribute valuable research findings to the existing body of agricultural knowledge.
Technology Adoption and Education: The use of UAVs in agriculture is a relatively new technology. Collaborative efforts with extension services, agricultural education programs, and technology adoption initiatives can help disseminate knowledge and promote the adoption of UAV technology for pest management across various crops and projects in the region.	**Environmental Stewardship:** Many projects in the Pacific Northwest focus on environmental stewardship and conservation. By reducing chemical pesticide usage through UAV-based precision pest management, the Red Raspberry project aligns with these environmental conservation efforts.

In summary, the Insect Pest Management project for Red Raspberry Crops using UAV technology in Washington State relates to various agricultural and sustainability initiatives in the region. It provides a technological and methodological framework that can be adapted and integrated into existing and future projects aimed at improving crop health, sustainability, and overall agricultural practices in Washington State and the Pacific Northwest. The sharing of knowledge and resources can lead to more effective and eco-friendly agricultural solutions that benefit the entire region.

The project will deliver the following specific benefits to producers and the oilseeds industry:

- **Increased Yield and Profitability:** The project will enable producers to effectively manage Mites, Cutworms, Leafrollers, Thrips and other pests, leading to higher Red Raspberry yields and improved crop quality. This, in turn, will boost profitability for Red Raspberry growers.
- **Reduced Production Costs:** By utilizing precision pest management with UAV technology, growers can reduce the need for chemical pesticides and optimize their application. This will result in cost savings associated with pesticide procurement and application.
- **Sustainable Agriculture Practices:** The project promotes sustainable agricultural practices by minimizing chemical pesticide use and reducing the environmental impact. This aligns with the growing demand for environmentally friendly and sustainable agriculture.
- **Crop Quality Assurance:** Improved pest management will ensure that Red Raspberry crops meet or exceed quality standards, making them more attractive to buyers and processors. This benefits the entire industry by maintaining product quality.
- **Pest Resistance Management:** Effective pest control measures will help delay the development of resistance among Mites, Cutworms, Leafrollers, and Thripss and other pests. This is essential for the long-term sustainability of pest management strategies.
- **Enhanced Market Competitiveness:** Red Raspberry producers will be better positioned to compete in regional and global markets, as high-quality, pest-controlled Red Raspberry will be more desirable to buyers and consumers.
- **Crop Rotation Support:** The success of crop rotation practices in the Pacific Northwest region depends on effective pest management. This project will facilitate the success of such practices by minimizing pest-related risks.

- **Technological Advancement:** The integration of UAV technology and data-driven pest management techniques will serve as a model for adopting advanced technology in agriculture. It will empower producers to keep up with technological advancements in the industry.

The benefits and results of the Insect Pest Management project for Red Raspberry Crops using UAV technology can be effectively transferred to others through various means:

- **Educational Outreach Programs:** The project team can organize and participate in educational outreach programs aimed at sharing knowledge and best practices with other producers, agricultural professionals, and stakeholders in the oilseeds industry. These programs can include workshops, seminars, and training sessions on the use of UAV technology for pest management and precision agriculture.
- **Extension Services:** Collaborate with agricultural extension services in Washington State and the Pacific Northwest to disseminate project findings, recommendations, and technological advancements. Extension services are well-positioned to reach a broad audience of growers and provide them with information and resources.
- **Research Publications:** Publish research findings, methodologies, and best practices in peer-reviewed scientific journals and agricultural publications. This will make the project's results accessible to researchers, agronomists, and anyone interested in implementing similar strategies.
- **Demonstration Farms:** Establish demonstration farms where the project's pest management techniques, including the use of UAV technology, can be showcased to other growers. Demonstrations provide a tangible way for others to see the benefits of the technology in action.
- **Collaborative Partnerships:** Collaborate with agricultural organizations, industry associations, and cooperative extension services to share project outcomes. These organizations often have well-established networks and can facilitate the dissemination of project results.
- **Online Resources:** Create a project website or online platform where growers and industry stakeholders can access project reports, data, videos, and other educational materials. This platform can serve as a hub for sharing project information and updates.
- **Industry Conferences and Workshops:** Present project findings at regional and national industry conferences and workshops. These platforms provide opportunities to reach a diverse audience of stakeholders and professionals in the oilseeds industry.
- **Collaborative Projects:** Collaborate with other agricultural projects and initiatives in Washington State and the Pacific Northwest to integrate UAV-based pest management into their practices. This cross-pollination of ideas and methods can enhance the adoption of the technology.
- **Agricultural Education Institutions:** Engage with agricultural colleges and institutions to incorporate project outcomes into their curriculum and research programs, ensuring that future generations of agricultural professionals are well-versed in these innovative techniques.

Conclusion: The proposed Insect Pest Management program for Red Raspberry crops using UAV technology offers an innovative and sustainable solution to combat the Mites, Cutworms, Leafrollers, and Thrips and other pests effectively. By integrating UAVs and data-driven strategies, we aim to enhance crop health, optimize pesticide usage, and increase Red Raspberry yields while minimizing environmental impact. This 3-year project aligns with the goals of modern agriculture, promoting sustainability and profitability for Red Raspberry growers.

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

Project Title: Management of Snails on Raspberry – Year Two

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

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

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

Justification and Background:

For reasons that are unclear the presence of snails in raspberry has increased recently. Feeding damage to foliage is removal of plant tissue between veins and on the edge of leaves. Snail damage tends to be heaviest along field margins. Weedy or grassy borders serve as excellent habitats for snails. Snails 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 snails but rather contamination of finished product.

A number of snail species can infest raspberries. No one has carried out research on these pests in raspberries in Washington so essentially nothing is known about their biology and control. Snail damage to raspberries can be extensive near field margins. Weedy, grassy or wooded borders serve as excellent habitat for snails, which describes most of the raspberry fields in Washington.

Snails have always been a problem in raspberry but for whatever the reason, they have become more of a problem in the past five years. There is a belief that in recent years there have been increased rain events (except for 2023) resulting in conditions more favorable to the development of mollusk pests. Growers have started applying more molluscicides, specifically metaldehyde baits. Snails are not as attracted to baits as are slugs. There are no registered baited pesticides for snails. The labeled rate allows up to 40 pounds but growers are commonly applying 5 pounds and make the applications repeatedly three times and up to 5 times. At the highest rate, metaldehyde costs about $90 an acre plus 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 snails fall into the harvested fruit as a contaminant. Snails are not always separated out on the packing line and there is zero tolerance for finding mollusks in frozen raspberry products.

The raspberry industry is interested in figuring out how to improve control of snails 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 snails 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 snails in raspberries.

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

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

Objective 1. Develop improved molluscide use patterns to better control snails in raspberry.

Procedures:

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

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

Anticipated Benefits and Information Transfer:

Our goal is to develop biological information that will allow improved control of snails. This information will be communicated to growers by providing written reports for distribution by the

Washington Red Raspberry Commission and in growers meetings such as the Co-op grower meeting and the Washington Small Fruit Conference.

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

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

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

The trial was carried out in 2023 as planned but due to an extreme drought there were essentially no snails in the trials or in any raspberry field. If this project is funded in 2024 and there are similar weather conditions that prevent a snail populations from reaching significant levels, the trial would be terminated early and there would be no costs charged for the last half of the trial expenses.

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:

- Resulted in a reduction of herbicide use in two trials.
- Resulted in similar herbicide effectiveness when compared to broadcast 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 2023, the Adverse Effect Wage Rates in Washington State is $17.97/hour, which together with Oregon, is the highest rate in the U.S.[2]. The 2021 minimum wage in the state is $15.74 per hour, which is also the highest in the country[3]. These figures are higher by about 3% and 9%, respectively compared to 2022 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 got worse due to the COVID-19 pandemic. Red rapberry 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 blueberry 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)

2023 Methods

Field Trials with Spot Sprayer

Issues with sprayer calibration delayed the initiation of trials until after harvest. Two trials were setup in two different 'Meeker' plantings with trial 1 being initiated on 8/18/23 and trial 2 being initiated on 8/25/23. In both trials plots consisted of one row (trial 1: 192 m, trial 2: 305 m) with four replications per treatment. For both trials treatments were: 1.) broadcast herbicide, or 2.) spot spray herbicide. Gramoxone SL 2.0 (paraquat, Syngenta, Basel CH) 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. 1). 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.

Weed Assessments

Weed density (by species) and height were quantified the day prior to herbicide applications by placing six ¼ m^2 quadrats randomly in raspberry rows for each 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 1 week, and then weighed again. Additionally, six 6 m areas within the row 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.

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 latest 'Meeker' enterprise budget (Galinato et al. 2023) was also used as basis for deriving the potential cost savings per acre (if any) if the alternative was adopted.

Results

Field Trials with Spot Sprayer

Weed Assessments

Weed density and height prior to herbicide application were similar across treatments for both trials (Fig. 2 & 3). Despite some notable outliers, 14 days after herbicide application both weed density and weed biomass was similar between treatments (Fig. 4 & 5). Visual control assessments from larger areas of the plots found similar effectiveness between treatments at 14 days after treatment (Fig. 6) and 28 days after treatment (not shown for brevity). Control ratings averaged >80% across these two assessments 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). For both trials, total herbicide applied was significantly less in spot spray treatments (Fig. 7) when compared to broadcast applications. It should be noted that the range of herbicide applied (across replications) varied considerably between trials. This was largely driven by the variation in the amount of primocanes hanging into the spray zone which triggered the spot sprayer.

Economic Analysis

The results showed that the spot spray treatment used fewer herbicides than the baseline, translating to significant cost savings of about 19% to 42%. If the alternative treatment is used, a grower can potentially save $21.28 to $47.04 per acre per year or about $638 to $1,411 per year given 30 acres of ‘Meeker’. 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 8.4 to 18.7 years, depending on the expected herbicide cost savings (Table 1). If other benefits like labor cost savings are included (e.g., when spraying less, there is less time spent mixing chemicals), the payback period would decrease.

Conclusion and Additional Thoughts

Spot spray technology did reduce herbicide use in two trials in ‘Meeker’ red raspberries post-harvest while maintaining control effectiveness. This technology still needs evaluation to determine the effectiveness at different times of the growing season and the payback period on the capital investment of the equipment. These trials both occurred post-harvest when weed pressure is typically higher. Future proposed trials would include spring trials where we predict to observe an even greater reduction in herbicide use than was found in these trials. Future research could focus on applying multiple products simultaneously in precise application zones, application of herbicides with mixed (pre & post) effectiveness, and as part of larger herbicide screens.

Figure 1. Weed-It Quadro Spray System.

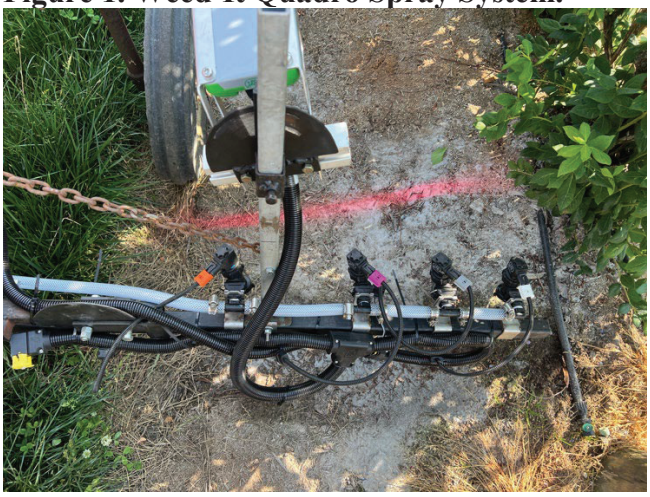

Figure 2. Weed density (1/4 m^2) ***before*** herbicide treatment in 'Meeker' raspberries (two trials), 2023.

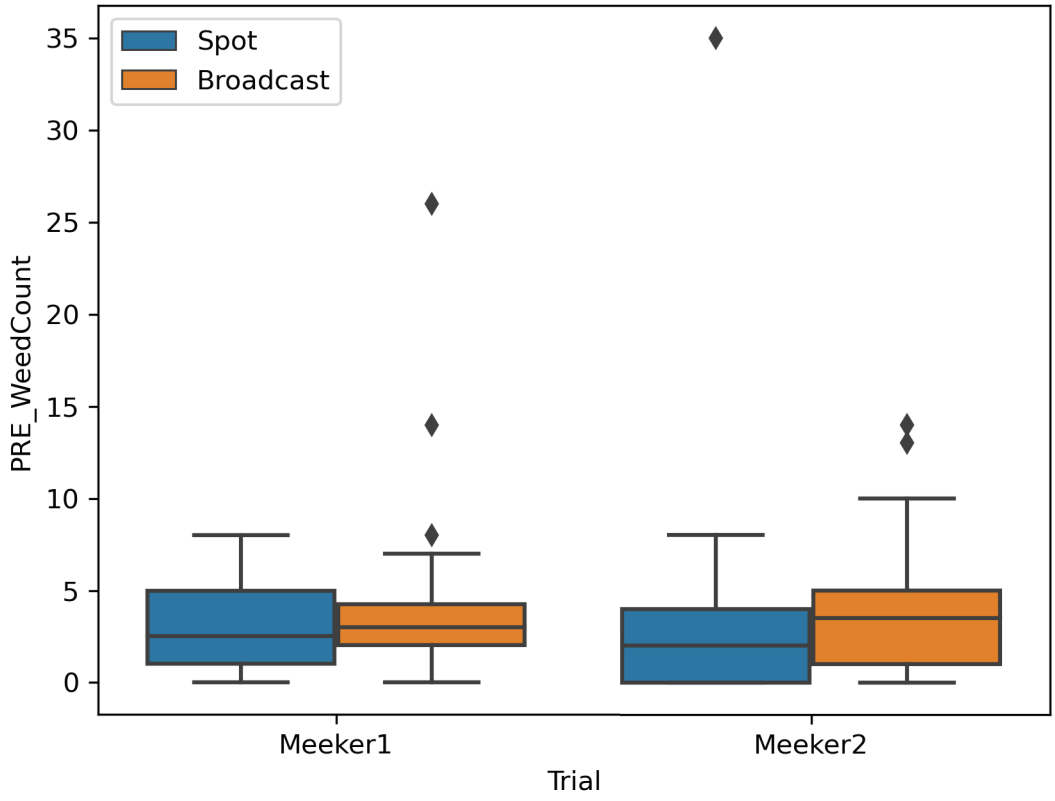

Figure 3. Weed height (cm) ***before*** herbicide treatment in 'Meeker' raspberries (two trials), 2023.

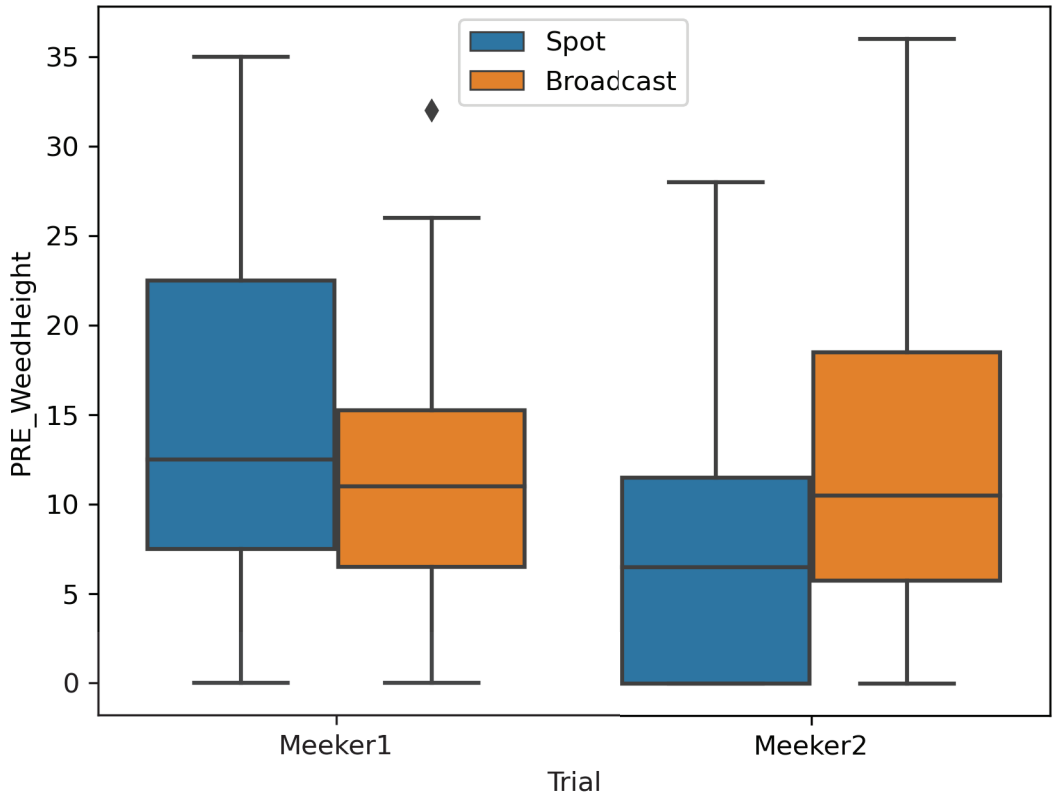

Figure 4. Mean weed density (1/4m^2) 14 days ***after*** herbicide treatment in 'Meeker' raspberries (two trials), 2023.

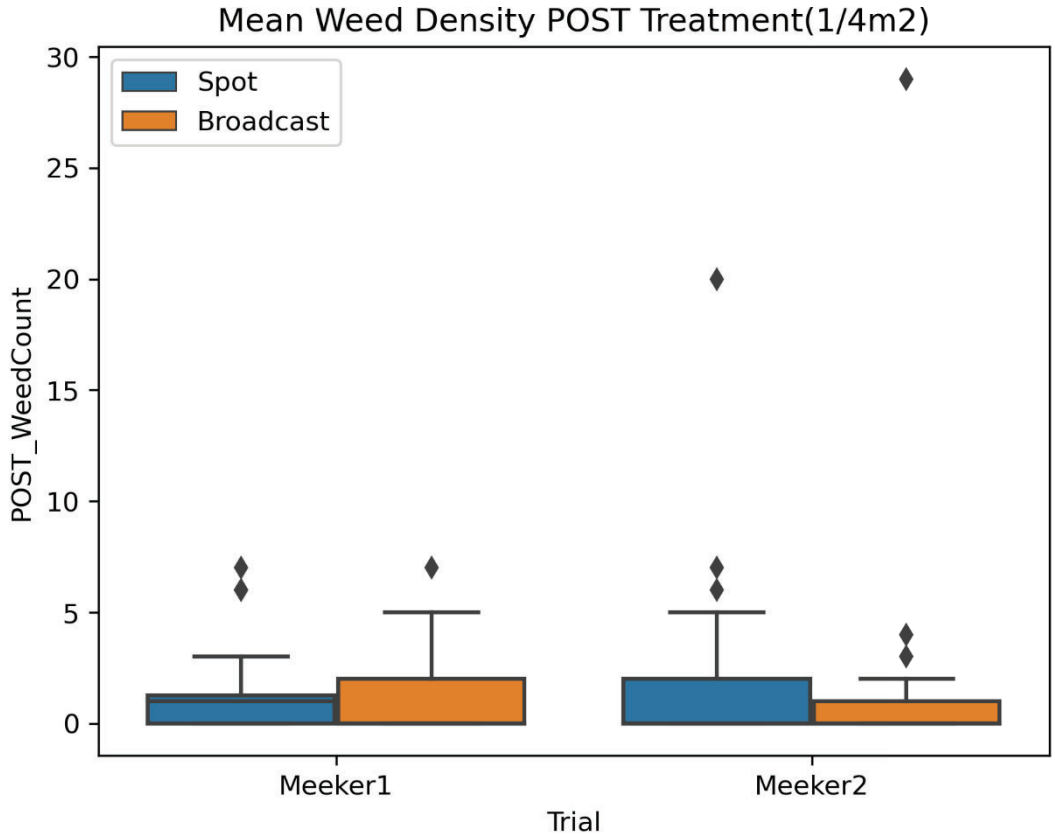

Figure 5. Weed biomass (g/1/4m^2) 14 days ***after*** herbicide treatment in 'Meeker' raspberries (two trials), 2023.

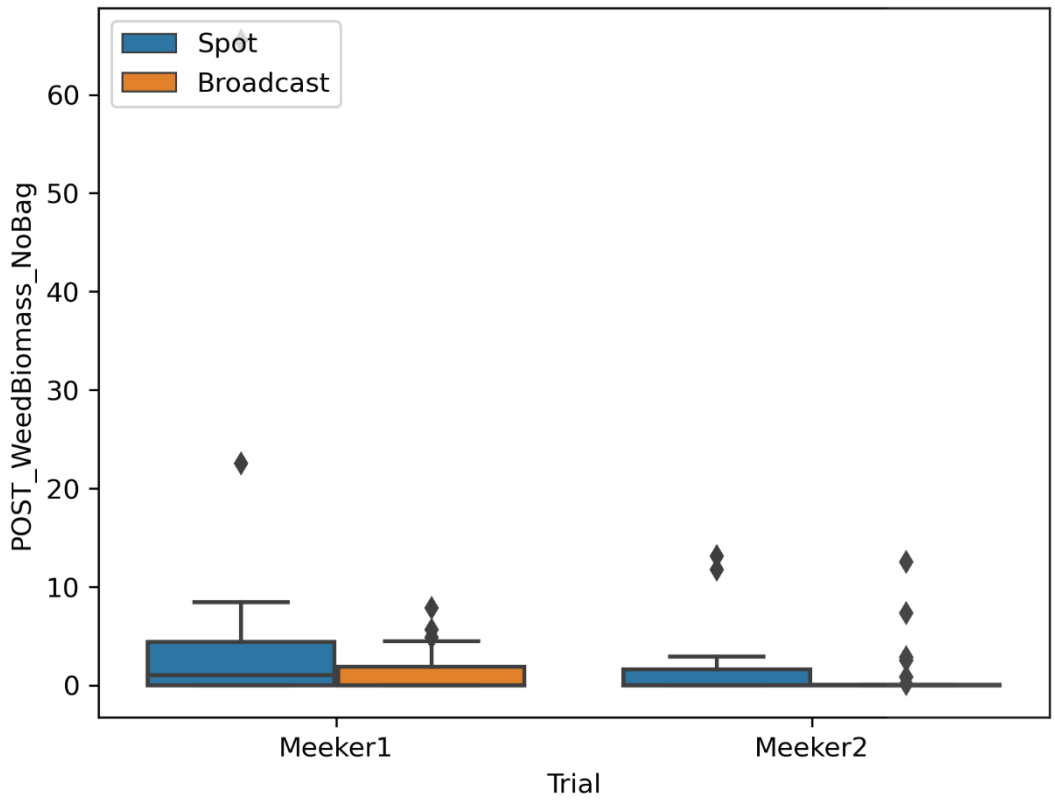

Figure 6. Percent control 14 days ***after*** herbicide treatment in 'Meeker' raspberries (two trials), 2023.

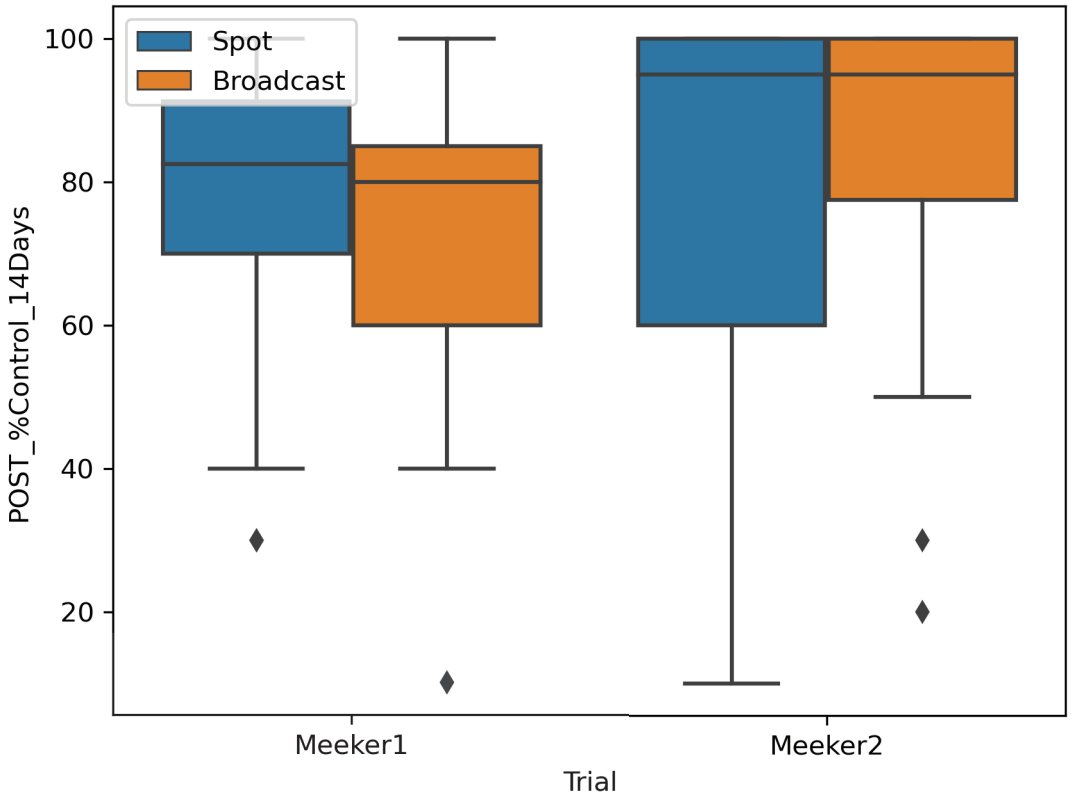

Figure 7. Total herbicide applied (ml) in 'Meeker' (two trials), 2023.

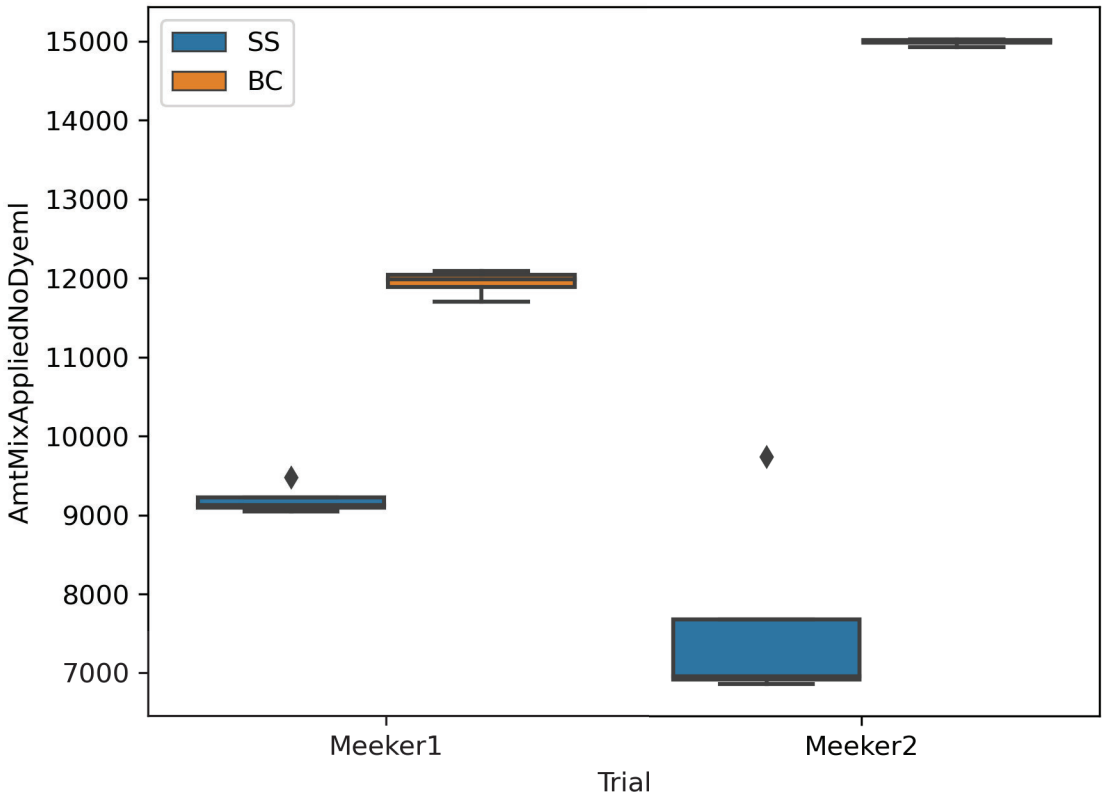

Table 1. Initial cost, potential savings, and payback period of spot spray equipment.

Variable	Cost, savings, payback period		Notes
	Herbicide costs = 19% lower than base	Herbicide costs = 42% lower than base	
Initial cost	$11,910	$11,910	Spot spray equipment
Annual savings	$638	$1,411	Herbicide cost savings
Simple payback period (years)	**18.66**	**8.44**	Initial cost divided by annual savings

Notes:
*Cost savings are 19% to 42% lower than the baseline herbicide costs ($3,360 per year for 30 acres).
**The estimate of the payback period assumes that the herbicide products in one trial is 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, thus the cost differential per year between the baseline and alternative is assumed to be 19% to 42%.

References:

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2024 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

Project Title: Using Spot Spray Technology in Red Raspberry Production Systems in Washington State

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

Total Project Request: **Year 1 $10626** **Year 2 $11433**

Description:

This project will evaluate spot spray technology for use in red raspberry production in Washington State through the following objectives:

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

Our outcomes are to determine whether this technology will lower production costs associated with weed management in red raspberry production systems.

Justification and Background:

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

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

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

Procedures:

Field Trials with Spot Sprayer (Obj. 1)
Six fields will be selected to directly compare the "business as usual" application of post-emergent herbicides alongside the use of herbicides applied with a precision sprayer (**automated spot sprayer**). Plots will be set up in a completely randomized block design with four replications. Each plot will consist of an entire row to accommodate commercial operations for a total of eight rows per field. Treatments will be: 1.) broadcast herbicide, or 2.) spot spray herbicide using Gramoxone SL 2.0 applied at 1 pint/A (20 PSI, 52 GPA) using a Weed-It Quadro spray system (Fig. 1). Trials will occur pre-harvest and post-harvest and herbicides will be mixed with water and spray dye.

Weed density and height will be quantified before herbicide applications (six ¼ m^2 quadrants) in raspberry rows. These locations will be flagged and marked. Fourteen days after application, weeds will be counted again, and biomass samples acquired. Samples will then be weighed, then dried, and then weighed again. Additionally, six 6 m areas within the row will be marked as these areas will be 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.

Economic Feasibility Assessment (Obj. 2)
A partial budget analysis will be conducted to estimate and compare the costs and benefits of the alternative (**automated spot sprayer**) against business-as-usual. The existing raspberry enterprise budget[4], adjusted to reflect current market prices, will be used as basis for the business-as-usual scenario. In the partial budget, the net change in profit that can be expected

from the alternative is estimated. The change can have one or more of the following effects: new or additional expenses; reduced or eliminated expenses; new or additional revenue; or lost or reduced revenue[5]. Results will inform us if using the automated spot sprayer for precise treatment of weeds will generate a gain or loss with respect to the current level of profit (baseline). In addition, we will undertake risk analysis by examining the sensitivity of profit in critical economic parameters, such as crop yield, output price, herbicide costs (material and labor), and fixed costs (i.e., spot spray technology). The return on investment for technology adoption will also be estimated given the above-mentioned sensitivity scenarios.

Anticipated Benefits and Information Transfer:

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

References:

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

Figures

Figure 1. Weed-It Quadro Spray System.

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

	2024
Salaries[1/]	$7,223
Time-Slip	$990
Operations (goods & services)	$398
Travel[2/]	$466
Meetings	$
Other	$
Equipment[3/]	$
Benefits[4/]	$2,356
Total	**$11,433**

Budget Justification
[1/]Specify type of position and FTE.
Schacht 7% FTE for 5 months @ $4334.90/month total $1517
Evalt 5% FTE for 5 months @ 4419.80/month total $1105
Non-student temporary employee 12hrs/month for 6 months @ 18$/hr total $1296
Galinato 8.33% FTE for 6 months @ $7260.42/month total $3629
Hoheisel 9% for 1 month @ $10797.80/month total $972

[2/]Provide brief justification for travel requested. Travel to and from on-farm trials 600 miles @ $0.665/mile total $399. Fuel for tractor 100 miles @ $0.665/mile total $67

[4/]Included here are tuition, medical aid, and health insurance for Graduate Research Assistants, as well as regular benefits for salaries and time-slip employees.
Benefits for Schacht @ 31.2% total $474
Benefits for non-student temporary employee @10.1% total $100
Benefits for Galinato @ 31.2% total $1133
Benefits for Evalt @ 31.2% total $345
Benefits for Hoheisel@ 31.2% total $304

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 Progress Report Format for 2023 Projects

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: 2023

Accomplishments:

A two-year trial was established in Lynden, Washington using 'Meeker' and 'WakeHaven'. Within each cultivar field, three calcium treatments were applied to 56-ft long plots replicated four times (n=12 plots per cultivar). Treatments included: 1) gypsum (Gypril @ 1 ton/acre ≈ 440 lbs/acre Ca; applied in March 2023), 2) foliar calcium (NUE CAL-8 @ 8 qt/acre diluted in 100 gal H_2O x 8 applications ≈ 164 oz/acre Ca) + non-ionic surfactant; applied weekly from June 13-Aug. 1, 2023), and 3) an untreated control. Foliar treatments were applied to coincide with peak calcium uptake periods determined in 2022 through this project. Yield, fruit size, fruit quality (firmness, total soluble solids, pH, and total titratable acidity), as well as leaf, fruit, and soil nutrient data were collected. Results from this project were presented at the International Society for Horticultural Science Rubus and Ribes Symposium in July 2023. Results will also be shared among raspberry growers attending the Small Fruit Conference in Lynden as well as the Great Lakes Expo in Grand Rapids, Michigan. Results from the project will provide information on when calcium is accumulated into developing raspberry fruits as well as methods and implications of increasing fruit calcium levels on yield and fruit quality.

Results:

Total yield of 'Meeker' was significantly greater from plants treated with gypsum compared to the foliar treatment and untreated control. 'WakeHaven' yield was unaffected by the treatments. All fruit quality variables as well as leaf and fruit calcium levels were statistically the same across treatments for both cultivars. Although fruit calcium levels did not differ by treatment, the foliar treatment led to greater calcium levels in the receptacle of 'WakeHaven' followed by the gypsum treatment. The untreated control had the lowest levels of calcium in the receptacle. Fruit calcium was overall low compared to the receptacle (0.10-0.11% Ca compared to 1.0-1.4% Ca). This suggests that it may be difficult to meaningfully increase levels in the fruits due to preferential accumulation in receptacle tissues. Soil calcium levels were also not different by treatment but were 14-25% higher when treated with gypsum for 'WakeHaven' only. We plan to repeat the experiment in 2024 but use higher rates of our fertilizer treatments.

Publications:

Silva, A.D., S. Orr, M. Kraft, M. Hardigan, B. Maupin, R. Pio, D.R. Bryla, and L.W. DeVetter. 2023. Calcium accumulation in developing fruits of raspberry and blackberry. Acta Hort. *In press.*

2024 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

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

PI: Lisa DeVetter
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Co-PI: Dave Bryla
Organization: USDA-ARS
Title: Research Horticulturist
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Address: 3420 NW Orchard Ave
City/State/Zip: Corvallis/OR/97330

Cooperators: None

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

Total Project Request: $60,386 **Year 1** $11,042 **Year 2** $13,774 **Year 3** $16,726

Other funding sources: Northwest Center for Small Fruits Research
Amt. Requested/Awarded: $30,378 (year 1)
Notes: This proposal was re-submitted and awarded in 2023.

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

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

To mitigate deficiencies and imbalances, growers often apply Ca fertilizers to soil or plant canopies (i.e., "foliar feeding"). However, information guiding and on the overall efficacy of these applications is mixed or lacking, particularly for raspberry. Vance et al. (2017) found foliar applications of Ca had no effect on fruit quality or shelf life in raspberry (*Rubus idaeus*), blueberry, strawberry (*Fragaria ×ananassa*), and blackberry (*Rubus* subgenus *Rubus*). Arrington and DeVetter (2017) also found similar results for commercially available foliar and soil-applied

Ca in blueberry. In contrast, Gerbrandt et al. (2019) found foliar Ca was able to correct deficiencies in blueberry when applied frequently and at high concentration from mid-bloom onward. Furthermore, calcium chloride was found to reduce raspberry softening and respiration rate in postharvest storage (Lv et al., 2020).

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

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

Objectives:

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

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

Objective 2. To evaluate methods to increase Ca concentrations in raspberry leaves and fruits, a two-year on-farm trial was established in 2023 with a grower-cooperator in Lynden, Washington. Given observed differences among cultivars in 2022, we used 'Meeker' and 'WakeHaven' for this objective. Our treatments included: 1) foliar applications of calcium; 2) soil applications of gypsum; and 3) an untreated control. These treatments were arranged in a randomized complete block design and applied to 56-ft-long plots replicated four times per cultivar. Calcium applications will follow the label and will be applied in 2023 and 2024. In both years, we will measure baseline and postharvest soil pH, EC, and macro- and micronutrients. Foliar and fruit nutrient analyses will also be completed yearly during standard tissue sampling times. Fruit and receptacle tissues will be evaluated separately at stages to determine Ca partitioning between fruits and the receptacles. Machine-harvestable yield and fruit quality (average berry size, firmness, total soluble solids, pH, and TA) will also be measured yearly to determine how the treatments impact these variables.

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

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

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

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

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

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

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

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

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

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

	2022	2023	2024
Salaries[1/]	$2,118	$7,530	$8,482
Time-Slip[2/]	$3,456		
Operations (goods & services)[3/]	$1,730	$1,984	$3,436
Travel[4/]	$522	$522	$590
Meetings			
Other[5/]	$800	$0	$0
Equipment			
Benefits[6/]	$ 2,416	$3,738	$4,218
Total	$11,042	$13,774	$16,726

Budget Justification

[1/] Technical support for technicians Emma Rogers and Brian Maupin in the Small Fruit Horticulture program at 0.5 month at 100% FTE in Year 1 and 1 month each at 100% FTE in Years 2 and 3.

[2/]Timeslip and student to support field and lab data collection ($18/hr x 24 hrs/wk x 8 weeks in Year 1. No timeslip requested in Years 2 and 3.

[3/]Field and work supplies, nutrient analyses, shipping, and publications.

[4]/Travel for Small Fruit Horticulture program for roundtrip travel for field data collection (90 miles round trip @ $0.655/mile for 10 trips per year). Note milage rates increased in Year 3.

[6/]Benefits for technicians Emma Rogers and Brian Maupin at 58% and 43.4%, respectively.

*Approved by Susan Kendall, Nov. 13, 2023.

2024 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

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

PI: Lisa DeVetter
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Title: Associate Professor
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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 2024 Terminating Year 2025

Total Project Request: $35,583 **Year 1** $16,748 **Year 2** $18,835

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 (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. 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). Recent fully expanded primocane leaves will be sampled every two weeks from mid-May 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 and 12 fields in total. Due to potential confounding effects, we will avoid any fields treated with foliar fertilizers. 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 in the Bryla lab for macro- and micronutrients. Leaf nitrogen will be analyzed using a combustion analyzer (TruSpec CN; Leco Corp., St. Joseph, MI), 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 (Optima 8300; Perkin Elmer, Waltham, MA). Soil samples will also be collected in the fall of 2024 and 2025 and analyzed for pH, EC, organic matter content, cation- and anion-exchange capacity, and nutrients by Brookside Laboratories in New Bremen, OH. 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 the optimal leaf and soil sufficiency ranges for 'Meeker' and the newer cultivars.

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.

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	$10,179
Time-Slip	$	$
Operations (goods & services) [2/]	$1,150	$2,650
Travel3[/]	$943	$943
Meetings	$	$
Other	$	$
Equipment	$	$
Benefits[4/]	$4,868	$5,063
Total	**$16,748**	**$18,835**

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 co-PI Bryla for sample processing and analysis ($1,000/year), soil sample analysis and shipping ($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 $0.655/mi x 16 trips/year).

[4/]Benefits for Small Fruit Horticulture program technicians, Emma Rogers (58%) and Brian Maupin (43.4%).

*Approved by Susan Kendall, Nov. 13, 2023.

PATHOLOGY

VIROLOGY

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

Project Title: Control of Cane Blight in Red Raspberries

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

Cooperators: Lisa Jones, Pacific Berries, Lynden.
Enfield Farms, Lynden.
Tom Walters, Walters Ag Research, Anacortes.

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

Total Project Request: Year 1- $15,000

Other Funding Sources: We have submitted a proposal to the Washington Commission on Integrated Pest Managementfor $18,000 to support this effort.

Background. A raspberry cane blight project was initiated in 2019 to develop a means to control cane blight. After the first year of research, the research site was removed by the grower. This resulted in an entire year setback on the project as the same applications needs to be made to the same plots to both the primocane and the subsequent year's floricane to effectively evaluate the treatments' efficacy. 2022 was the final year of this project. Overall, efficacy results against cane blight were disappointing with only one treatment providing much control. However, use of Velum Prime for cane blight control using timings for nematode control provided a great deal of reduction in root lesion nematode numbers. Luna Tranquility (same active ingredient as Velum Prime) and Miravas were the most effective products at reducing cane blight in raspberry.

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

irrigation during harvest has increased disease incidence because spores are disseminated in splashing water. Young canes are more rapidly infected while older canes of raspberry are more resistant to infection in the fall.

Northwest Plant Company cultivars (WakeField, WakeHaven), Driscoll's cultivars and Chemainus appear to have a comparatively high level of sensitivity to this disease. In 2015, older WakeField plantings where cane blight had not been managed had up to 40% yield losses. WakeField represents about 30% of Washington's raspberry acreage and up to 50% of the state production. There are non-chemical control options that can reduce infections including pruning out infected canes, avoiding excess nitrogen, adjusting harvester catcher plates to reduce wounding, leaving cane stubble as short as possible and minimizing humidity during infection periods. However, despite the use of these tactics the disease has become a worsening problem. The primary means of controlling the disease is expected to be fungicides. Currently, the products recommended for control of cane blight are Tanos (famoxadone (Group 11), cymoxanil (Group 27)) and QuiltXcel (propiconazole (Group 3) and azoxystrobin (Group 11)), although cane blight is not on either label. Tanos requires rotation with fungicides containing different modes of action. The only products registered on caneberries that have cane blight on the label are copper and lime sulfur products (14 total products between the two types of products.) However, lime sulfur cannot be applied in season and copper is not thought to be very effective. One Washington raspberry grower found that alternating Tanos with Switch (Group 9 and 12) and Pristine (Group 7 and 11) seemed to reduce cane blight.

Lisa Jones, a Ph.D. plant pathologist with Pacific Berries, has carried out field and laboratory investigations on cane blight including the first identification of the disease on Wakefield raspberry in 2015. She has conducted lab bioassays screening selected fungicides against cane blight and found that Switch and Pristine were the most effective, with Kenja (isofetamid (Group7)) and Tanos being intermediate in effectiveness and Decree (fenhexamid (Group 17)) and PhD (polyoxin D) were relatively ineffective. A concern with applications of these products is that they occur during timings for *Botrytis*. Applications of products like Switch and Pristine have implications for resistance management. Drs. Jones, Walters and Schreiber propose to screen various fungicide use patterns for their ability to control cane blight in bearing raspberries in addition to collecting biological information on this disease. In 2021, this effort was expanded to include efficacy of Velum Prime against root lesion nematodes. This will be expanded in 2024. This is the only research being conducted against this disease on raspberries in the United States.

New Developments in Cane Blight Management. Possible Game Changer. However, recent research out of the southeastern U.S. on cane blight indicates that the approach Schreiber took, which is the use of *Botrytis* fungicides 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 was assumed to be the most effective means of control. Based on caneberry research in the southeastern U.S., the new recommendations for cane blight are to start

applications much earlier, more often, and use some different fungicides than were previously used. The new recommendations have applications start at delayed dormant (not at prebloom as before), then apply at 6 inch shoot length and again before prebloom, early bloom, full bloom, petal fall, and cover sprays through harvest. This program is probably ten applications as opposed the previous approach of six applications. The products recommended by southeastern caneberry pathologists are Abound, Cabrios, Pristine, and Quilt Xcel. Captan was described as having fair efficacy. Since this product is commonly used in blueberries, andshould be included, as well as Miravas Prime and Luna Tranquility.

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.

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

Objective 1. Generate data on fungicide efficacy against cane blight.

Procedures: We propose to conduct efficacy trials in two susceptible raspberry varieties, most likely WakeHaven and WakeField or Chemainus at separate locations. 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 a reduction of symptoms on the floricanes in year two. We estimate that 10 or more applications will be required to control this pest. A third year of testing would double the amount of efficacy data available.

Anticipated Benefits and Information Transfer:

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

Budget:	**2024**	**2025**	**2026**
Salaries	3,000	3,000	3,000
Operations			
Travel	950	950	950
Contract Research	10,000	10,000	10,000
Benefits	1,050	1,050	1,050
Total	$**15,000**	**$15,000**	**$15,000**

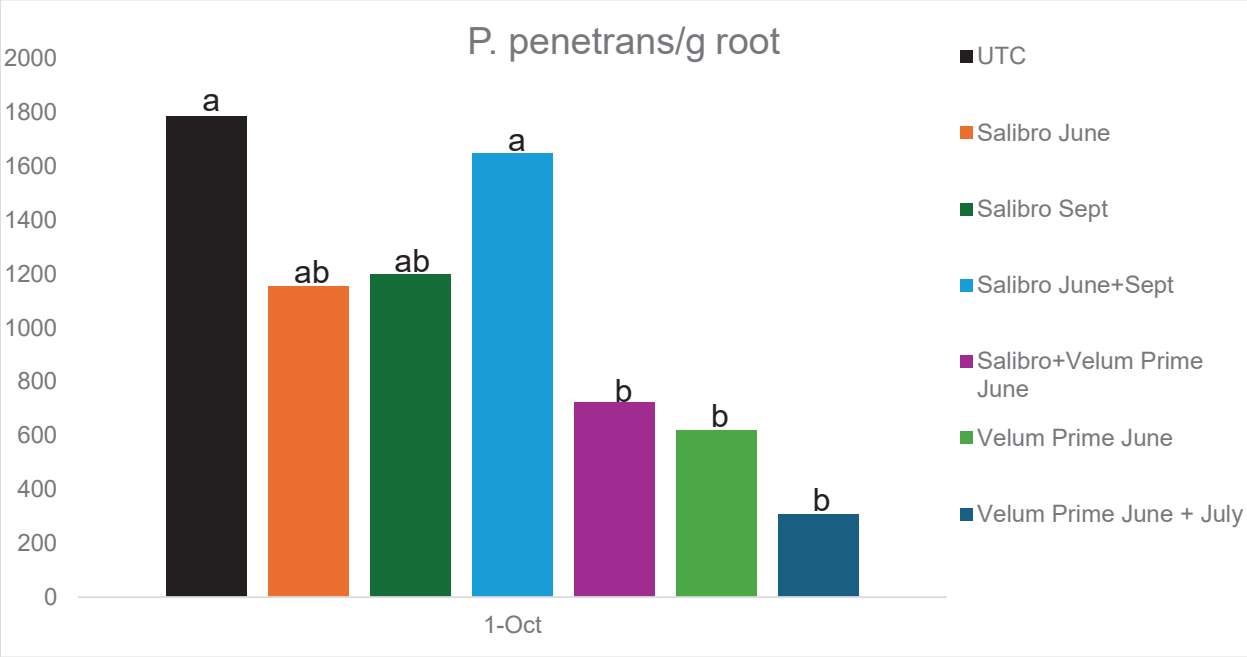
The funds for Contract Research are for chemical applications by Tom Walters. Pacific Berries will donate expenses and lab capacity for the trial for Dr. Jones. Enfield Farms will donate the trial site and cooperate with coordinating applications in the field.

Title: Extending the lifetime of plantings with novel post-plant nematicides
Personnel: Thomas Walters, Walters Ag Research; Inga Zasada, USDA-ARS HCRL
Reporting Period: 2023
Accomplishments:

- Confirmed efficacy of fluopyram (Velum Prime) drip applications to control root lesion nematode (*Pratylenchus penetrans*) in established raspberry plantings.
- Did not confirm efficacy of fluazindolazine (Salibro, Reklemel) drip applications for the same use.
- Confirms findings in BC and in another WA trial suggesting fluopyram efficacy. This is the only effective, labeled nematicide application for established plantings we are aware of.

Results: A cooperating grower identified a field with significant *P. penetrans* populations. Pretreatment root and soil samples were collected June, 2022. Plots were laid out with four replicate plots/treatment and each plot 10 x 30 ft long. Applications were made June 27, July 18 and September 1. Reklemel was applied at 2 lb a.i./a, and Velum Prime was applied at 6.84 fl oz/a. Products were applied through drip line, applying approximately 0.25-0.5 inches of water to the beds.

Root and soil samples for nematode analysis were collected June 21 (pretreatment), July 28, August 28, and October 1. They were processed in the Zasada lab at USDA-HCRL. There were no significant differences among treatments in the Pretreatment, July 28, or August 28 samples. In October 1 samples, *P. Penetrans*/g root was lower in Velum Prime-treated (below).



Publications:

- Nematicide use in Raspberries. Oral presentation, Small Fruit Conference, Lynden WA, Nov 30
- Note in Small Fruit Update (planned, winter 2023-2024)

2024 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

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

PI:
Tom Walters
Walters Ag Research
360-420-2776
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15696 Yokeko Dr
Anacortes WA 98221

Co-PI:
Inga Zasada
Research Plant Pathologist
USDA-ARS HCRL
541-738-4051
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3420 NW Orchard Dr
Corvallis OR 97330

Cooperators:

Year Initiated 2023 Current Year 2024 Terminating Year 2024

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

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

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 (details in project report).

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. Reklemel 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.

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:
We will continue research conducted in year 1 to determine whether these treatments can reduce *P. penetrans* and/or *X. bakeri* population densities with a single year's treatment. Depending upon first year's results, we plan to repeat the treatments the following year in this or another field.

Procedures:
This is year 2 of a two year project. In year 1, a cooperating grower identified a field with high *P. penetrans* populations. We applied and confirmed the efficacy of Velum Prime on *P. penetrans*. In year 2, we will sample the 2023 trial to monitor the duration of fluopyram's efficacy. We will also establish two trials on fields with *X. bakeri* (dagger nematode) populations. We have already presampled one grower's fields to confirm presence of both *Pratylenchus* and *Xiphinema*. At the request of another grower, we will presample a location for a second trial. Both trials will be carried out simultaneously. Pretreatment root and soil samples will be collected June, 2024. Plots will be randomized and laid out, with four replicate plots/treatment and each plot 10 x 30-60 ft long. First treatments will be applied early

June 2024. Additional treatments will be applied early July and early September, according to the table below. Reklemel will be applied at 2 lb a.i./a, and Velum Prime will be applied at 6.84 fl oz/a. Products will be applied through drip line, applying approximately 0.25-0.5 inches of water to the beds.

Treatment	Product	Application	Sampling
1	UTC		June, July, September
2	Velum Prime	June	June, July, September
3	Velum Prime	June, July	June, July, September
4	Velum Prime	June, September	June, July, September
5	Velum Prime	September	June, July, September
6	Reklemel	June, September	June, July, September
7	Reklemel+Velum Prime	June	June, July, September

Samples for nematode analysis will be collected approximately 1 month after treatment, also according to the table. Samples will be processed in the Zasada lab at USDA-HCRL Corvallis, producing results based on *P. penetrans*/g fresh weight of roots and *P. penetrans* and *X. bakeri* numbers/100 g soil. Treatments will be considered effective if they reduce *P. penetrans* and/or *X. bakeri* population densities one month or more after treatment.

Anticipated Benefits and Information Transfer:

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

References:

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

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

	2023	2024	2025
Salaries[1/]	$3,500	$5,500	$
Time-Slip	$ 500	$ 750	$
Operations (goods & services)[2/]	$1,500	$3,000	$
Travel[3/]	$ 345	$ 345	$
Meetings	$	$	$
Other[4/]	$ 600	$ 600	$
Equipment	$	$	$
Benefits[4/]	$	$	$
Total	**$6,445**	**$10,195**	**$**

Budget Justification

[1/] Walters, 5.5% FTE, benefits included.

[2/]Sample processing, Zasada lab

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

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

Progress Report
Washington Red Raspberry Commission

Project No: TBD

Title: Virus testing of PNW public raspberry breeding programs.

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

Reporting Period: 2023

Accomplishments:

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

In recent years we have tested and identified several new USDA red raspberry selections that are productive and machine harvestable and made these germplasm accessible as clean, virus-free plant material at regional nurseries. Additionally, we have continued to provide machine harvest yield and fruit quality assessment of promising WSU selections in the northern Willamette Valley. Since 2020 we have verified the performance and machine harvestability of several recent selections including WSU 2069, WSU 2088, WSU 2087, and WSU 2130. USDA selections made available at nurseries have included ORUS 5106-1 with excellent internal color and flavor and yields similar to Wakefield, ORUS 4974-1 which has shown excellent plant health and high yields with improved heat tolerance, and a number of fall-fruiting selections that offer season extension beyone the regular floricane season, including ORUS 4487-1, ORUS 4858-2, ORUS 5209-1, and ORUS 5250-1, and new cultivar 'Finnberry'.

In 2023 the funds allocated for project 'Virus testing of PNW public raspberry breeding programs' were used to test raspberry plots dating from 2018-2022 (1-5 years old) and determine the infections status of breeding plots for three viruses: RBDV, SNSV, and ToRSV.

Results:
We performed virus testing by ELISA test for three important viruses that effect raspberry in the PNW: raspberry bushy dwarf virus (RBDV), strawberry necrotic shock virus (SNSV), and tomato ringspot virus (ToRSV). Testing was conducted for all trial plots at the OSU North Willamette Research and Extension Center (OSU-NWREC) in Aurora, OR, the foundation/parental block plots located at OSU Lewis Brown Farm in Corvallis, OR, and virus quarantine fields located at the OSU Vegetable Farm in in Corvallis, OR. This totaled roughly 530 raspberry plots to-date. The results have identified infected plant material, indicating the susceptibility of a range of selections and cultivars contained in the USDA raspberry breeding material (**Table 1**), and identifying plots that are safe or unsafe to use for generating new breeding families. Both RBDV and SNSV appear to readily infect many red raspberry genotypes at both the OSU-NWREC and research farm locations in Corvallis. Certain genotypes appear slower to become infected with only a handful of total plots indicating infection after 3-5 years, whereas other became infected after only 1-2 years. SNSV was the most common viral infection, followed by RBDV. ToRSV appears to pose the lowest risk of

infection at the moment, with only a single plot of one selection (ORUS 4715-2) identified as containing the virus. This project has succesffully identified clean plant material for generating new breeding populations, while excluding infected plants from use as parents. 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.

- **RBDV –**
    - Approximately 25% of red raspberries indicated susceptibility to RBDV infection at the OSU-NWREC.
    - Notable selections that have been planted in 2018 or 2019 (5+ year old plots) and remain free of RBDV infection include: Cascade Harvest, Heritage, Kokanee, Meeker, ORUS 4725-1, ORUS 4858-2, ORUS 4978-3, ORUS 5114-1, Polka, Vintage, Wakefield, Wakehaven, WSU 2605, and WSU 2376
- **SNSV –**
    - Approximately 35% of red raspberries indicated susceptibility to SNSV infection at the OSU-NWREC.
    - Notable selections that have been planted in 2018 or 2019 (5+ year old plots) and remain free of RBDV infection include: Cascade Harvest, Heritage, ORUS 4858-2, ORUS 4961-1, ORUS 4965-3, ORUS 4974-1, ORUS 4978-3, Wakefield, Wakehaven, WSU 2069, WSU 2277, and WSU 2376.
- **ToRSV –** We identified a single red raspberry plot containing ORUS 4715-2 that was infected with ToRSV.

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 Environments: Mapping Che Genetics, and Growing Cond Flavor
DeVetter, Bryla, **Hardigan**, **Hoashi-Erhardt**	USDA Specialty Crop Multi-State Program	$1,000,000	09/2023/09/2026	10%	Beat the Heat - Mitigating He Caneberry
Hardigan, Luby	USDA-Northwest Center for Small Fruit Research	$50,000	09/2022-09/2023	10%	Evaluating the potential of ge predicting blueberry fruit qua season in Pacific Northwest g
Stockwell, Hardigan	USDA-Northwest Center for Small Fruit Research	$98,000	09/2022-09/2024	5%	Assessing the role of Gnomon other fungal cane blight patho Collapse
Hoashi-Erhardt, **Hardigan**, Zasada, Dossett	USDA-Northwest Center for Small Fruit Research	$135,000	09/2023-09/2025	10%	Genomic Prediction for Quan Root Lesion Nematode in Ra
Hardigan, Strik	Oregon Raspberry Blackberry Commission	$36,940	09/2023-09/2024	10%	Cooperative Caneberry Breed Cultivar and Selection Evalua
Pending:					

Appendix II: Tables

Table 1. Susceptibility (S) vs. clean (-) status for relevant cultivars and nursery list selections tested at OSU-NWREC in 2023 for RBDV, SNSV, and ToRSV. Clean status does not guarantee resistance, only that the tested plants did not contain the 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.

Principal Investigator: Michael Hardigan, Research Geneticist, USDA Corvallis

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

Year Initiated __2023___ Current Year 2024-2025 Terminating Year _2025_

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

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

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

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

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

Anticipated Benefits and Information Transfer: (<100 words)

Virus-infection status of raspberry breeding selections. Mitigation of virus spread within PNW breeding populations. The breeding programs will continue to develop cultivars and advanced selections with better performance or fruit characteristics than current 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)[2]	$3,000	$3,000	$3,000
Travel	$	$	$
Meetings	$	$	$
Other	$	$	$
Equipment	$	$	$
Benefits	$	$	$
Total	**$6,000**	**$6,000**	**$6,000**

Budget Justification

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

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

Washington Red Raspberry Commission: Progress Report Update

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

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Year Initiated 2022 Current Year 2023 Terminating Year 2024

Relationship to WRRC Research Priority(s):
Priority group #1 "Fruit rot, including pre-harvest, postharvest, and/or shelf life"

Objectives:

We hypothesize, that *Botrytis* spp. population structures in Washington red raspberry fields are evolving.

Botrytis is a "high risk" pathogen for the development of fungicide resistance. This is due to its inherent genetic diversity, and rapid production of millions of spores. Unfortunately, applying fungicides to control the pathogen may select for fungicide resistant variants. Over time, chemical control can select for pathogens that are resistant to multiple fungicide chemistries, which we have been observing in Whatcom County.

The objectives of this research are to profile fungicide resistance and genetic diversity of *Botrytis* spp. in red raspberry fields in northwestern Washington.

Current results:

We collected 1,176 *Botrytis* spp. isolates from 12 commercial red raspberry fields in Whatcom County, WA. Fields were sampled during the 2022 and 2023 growing seasons, at three red raspberry developmental stages each year: overwintering / early-season (ES) ~mid-January, bloom / mid-season (MS) ~mid-May, and harvest / late- season (LS) ~ mid-July.

This culture collection is the foundation for both fungicide sensitivity assays, as well as studies on genetic diversity of *Botrytis* in these fields. In 2022, the isolates of *Botrytis* were obtained from symptomatic and asymptomatic host tissues. The tissues were incubated in dark at 22°C and then an aseptic 'single-spore' isolation technique was used to obtain one representative isolate from each tissue sample. Each *Botrytis* isolate was stored at -20°C in cryo-vials containing a solution of glycerol / milk (35% and 7% w/v respectively). In 2023, we isolated clean cultures of *Botrytis* from each tissue for fungicide sensitivity assays, but did not undergo the process of 'single spore' isolation for the population analysis of *Botrytis* communities.

DNA has been extracted from all the 2022 growing season *Botrytis* isolates (n= 485) (Lee et al. 1988). A subset of these *Botrytis* isolates (n=96) are being used to determine which of the genetic regions (microsatellite markers) will be useful to assess genetic variability and population structures of *Botrytis* isolates on red raspberry in Whatcom county fields.

Agar media containing six different fungicides (technical grade) were used for *in vitro* fungicide-sensitivity assays based on *Botrytis* spore germination (Table 1). To differentiate

between sensitive and reduced sensitive isolates of *Botrytis*, discriminatory doses were determined from previously developed protocols (Weber and Hahn, 2011; Saito et al. 2016; Cosseboom and Hu, 2021) and experimental screening using predetermined concentrations on a subset of 36 *Botrytis* isolates.

In brief, 5 µl of the conidial (*Botrytis* spore) suspension (1×10^5 conidia per ml) was placed onto control media (no fungicide) and media containing the test fungicide. Each test had two replications for each *Botrytis* isolate and each test material. Conidial germination was assessed visually using a microscope after a 14-16 hour incubation period at 22°C and in the dark. Assessments of conidial germination were categorized based on germination and fungal outgrowth from the spore (aka germ tube length) in comparison to the positive control (the same isolate of *Botrytis* on media without a fungicide added). The rating scale was: sensitive (0-20% germination and growth compared to the control), moderate (>20% to < 50%), or reduced sensitivity (> 50%, germination and growth compared to the control). To date, we have screened 468 *Botrytis* isolates (n= 194 single spore isolates, and n= 274 clean isolates), which varied in their frequency to reduced sensitivity among each field and fungicide. (Figure 1, Figure 2).

We also placed fungal spore traps in five of the twelve cooperating grower red raspberry fields in 2022 and 2023. The spore collection rods were replaced weekly, resulting in 368 and 391 collection points for the 2022 and 2023 growing seasons respectively. DNA has been extracted for all 759 collection rods. To quantify airborne inoculum levels of *Botrytis* in a growing season, we will conduct quantitative real-time PCR assays.

Table 1. Fungicides and discriminatory doses used in this study.

FRAC code	Fungicide	Discriminatory Dose (ppm)	Growth Medium
9	Cyprodinil	4	0.5% Sucrose agar
9	Pyrimethanil	4	0.5% Sucrose agar
7	Isofetamid	5	0.5% Yeast extract agar
7	Fluxapyroxad	10	0.5% Yeast extract agar
7	Boscalid	10	0.5% Yeast extract agar
7	Fluopyram	5	0.5% Yeast extract agar

Figure 1. Frequency of Botrytis *isolates (n=432) with reduced sensitivity to technical grade fungicides.*

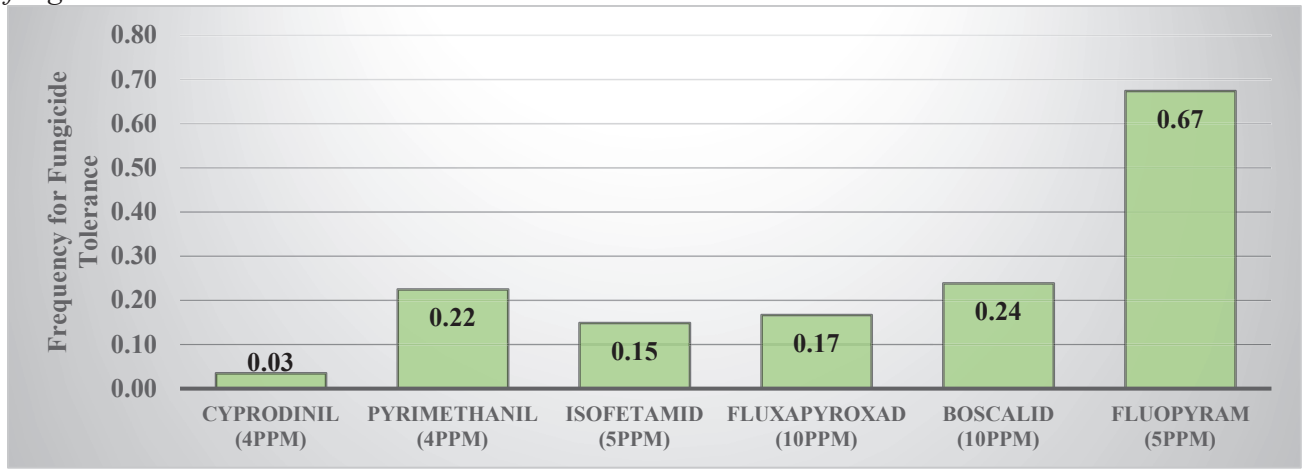
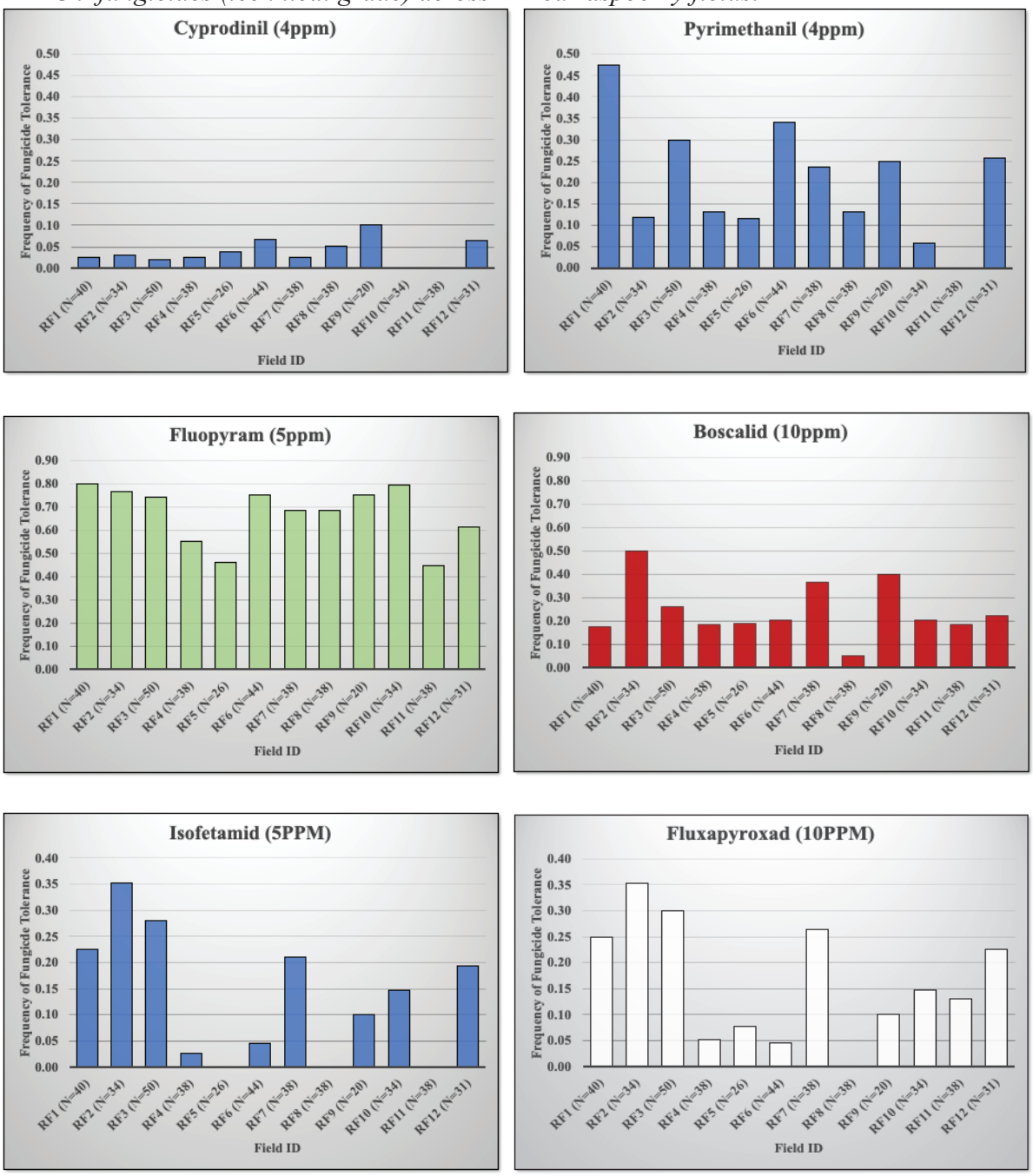


Figure 2. Frequency of Botrytis *isolates (n=432) with reduced sensitivity to select FRAC 7 and FRAC 9 fungicides (technical grade) across 12 red raspberry fields.*



Conclusions:

Our results indicate the presence of *Botrytis* isolates with reduced sensitivity to multiple fungicides in Washington commercial red raspberry fields. Sensitivity varied greatly among fields and with tested fungicides. We will continue to screen and monitor our remaining *Botrytis* isolate collection to FRAC 7 and 9 fungicides. Currently, we are investigating mutations

associated with SDHI resistance by sequencing a subset of boscalid-resistant *Botrytis* isolates identified in our screening assays.

References:

Lee, S. Milgroom, M., and Taylor, J. 1988. A rapid high yield mini-prep method for isolation of total genomic DNA from fungi. Fungal Genet. Newsl. 35:23-24

Weber, R. W. S., and Hahn, M. 2011. A rapid and simple method for determining fungicide resistance in *Botrytis.* J Plant Dis Prot. 118:17–25.

Saito, S., Michailides, T. J., and Xiao, C. L. 2016. Fungicide resistance profiling in *Botrytis cinerea* populations from blueberry in California and Washington and their impact on control of gray mold. Plant Dis. 100:2087–2093.

Cosseboom S. D., and Hu, M. 2021. Identification and characterization of fungicide resistance in *Botrytis* populations from small fruit in the Mid-Atlantic United States. Plant Dis. 10.1094