2022 Research Proposals

and

2021 Research Reports

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

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2022 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
- Fruit rot including pre harvest, post-harvest, and/or shelf life.
- 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

#2 priorities

- Understanding soil ecology (*including biology, nutrient balance*) and soil borne pathogens and their effects on plant health and crop yields.
- Foliar & Cane diseases – i.e. spur blight, yellow rust, cane blight, powdery mildew
- Root weevils
- Cutworm, leafroller management
- Soil fumigation techniques and alternatives to control soil pathogens, nematodes, and weeds

#3 priorities

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

2022 WRRC Research Budget

PAGE	PROJECT TITLE	RESEARCHER (S)	REQUEST	DRAFT 1	Other $	Source	Approved
PLANT BREEDING			49.68%	0.00%			0.00%
4	Red Raspberry Breeding, Genetics and Clone Evaluation	Hoashi-Erhardt	$87,701		$253,967	NWCSFR	
15	Coordinated Regional on-farm Trials	NWBF - Walters	$5,128		$1,200	in-kind	
20	An Economic Fingerprinting Set for Red Raspberry - 2019	Zurn/Bassil					
22	Red Raspberry Cultivar Development	Dossett	$10,000		$236,000	Ag Canada	
ENTOMOLOGY			20.45%	0.00%			0.00%
30	Two-Spotted Spider Mites in Red Raspberries	Schreiber	$12,495		$12,955	WSCPR	
39	Developing an Insect IPM Program	Schreiber	$11,984		$12,310	WSCPR	
43	European strawberry blossom weevil (Anthonomus rubi) survey	Looney/Benedict	$17,859		$78,712	APHIS	
WEEDS			0.00%	0.00%			0.00%
PHYSIOLOGY			9.52%	0.00%			0.00%
52	Determining optimal timing of mulch removal	DeVetter	$8,660				
59	Calcium accumulation and increasing fruit uptake	DeVetter	$11,042				
PATHOLOGY/VIROLOGY			17.61%	0.00%			0.00%
66	Management of Fungicide Resistant Botrytis in Raspberries	Schreiber					
75	Control of Cane Blight in Red Raspberries	Schreiber/Jones	$10,000		$16,000	WSCPR	
92	Extending the lifetime of plantings with novel post-plant nematicides	Walters	$6,445			in-kind	
95	Characterization of Botrytis on red raspberries	Stockwell/DeLong	$20,000		$20,000	WSCPR	
SOILS			0.00%				0.00%
100	Application of Soil health concepts to red raspberry production	Zasada	$5,675				
104	Measuring and Mitigating Soil Compaction	Griffin/LaHue					
	Total Production Research		**$206,989**	**$0**	**$631,144**		**$0**
	Research Related	WRRC expenses	$3,500	$3,500			$3,500
	Small Fruit Center fee		$2,500	$2,500			$2,500
	TOTAL		**$212,989**	**$6,000**			**$6,000**
	2022 Research Budget		$180,000	$174,000	report only	applied	

PLANT BREEDING

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

PI:	Wendy Hoashi-Erhardt	**Co-PI:**	Lisa Wasko DeVetter
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Reporting Period: 2021

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

Accomplishments:
Cultivar and prospective cultivars.
'Cascade Premier' was released in 2017. It is exclusively licensed to Northwest Plant Company and plant sales are outlined in Figure 1. 'Cascade Premier' is a cultivar that machine picks well. It has demonstrated good tolerance to root rot, better than 'Meeker' or 'Cascade Harvest'. It is an early season cultivar. In terms of fruit quality, it has large fruit, good firmness, and good flavor. It has similar pH, titratable acidity, and total phenolics content similar to 'Willamette' fruit, and anthocyanins levels similar to 'Meeker'.

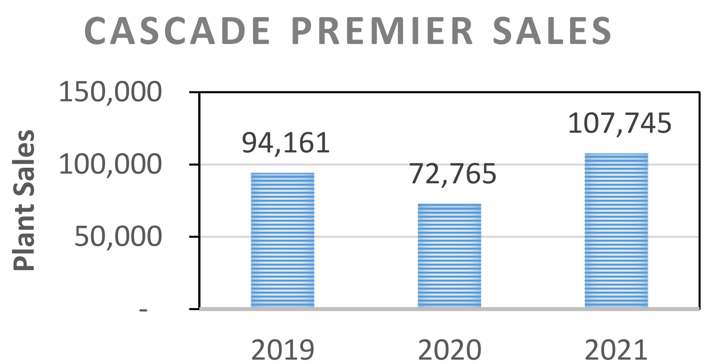

Figure 1. Plant sales of 'Cascade Premier', 2019-2021.

WSU 2188 is a very promising advanced selection and is being tested at several regional sites in grower trials. Overall, WSU 2188 has large fruit, good firmness, and good flavor. Its season is temporal with 'Meeker'. The WSU plant breeding program successfully leveraged WRRC funding on the development of WSU 2188 and 'Cascade Premier' to procure new funding from the NW Center for Small Fruit Research for a 3-year research project to evaluate 'Cascade Premier' and WSU 2188 in multi-acre plantings to generate large volumes of fruit for extensive evaluations of IQF performance. This project runs 2020-2023. The program expects to be able to release WSU 2188 in 2023.

WSU 2029 is a floricane-fruiting red raspberry cultivar with good yields of medium large, firm fruit that are bright red colored and have excellent flavor. This cultivar is notable for its very late fruiting season and its high tolerance to *Phytophthora rubi* (Man in 't Veld, 2007) in field trials. 'WSU 2029' should be adapted to raspberry growing regions in the Pacific Northwest and is well suited to fresh production. The program hopes to be able to release WSU 2029 under a nonexclusive license in 2022.

WSU 1607 ('Cascade Gem') was licensed exclusively in Europe with Meiosis, with no release in North America. 'Cascade Gem' has sold 430,000 long canes in the UK between 2021-2022 for fresh market production, bringing significant royalty income back into the plant breeding program. This is a success story for overseas technology transfer that doesn't compete with Washington's processed red raspberry industry but brings in royalty income to support the breeding program.

Crosses/selections.
New crosses were performed in 2021 between parents with traits of excellent machine-harvestable yield, berry firmness, and root rot tolerance. These seeds are being germinated to form the new seedling field to be planted in 2022.

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

Establish-ment year	Number of seedlings	Activities in 2021
2019	~7700	Generated from crosses made in 2018. Maintained for two years, selections made in 2021, now being removed.
2020	~ 3800	Seedling field failed – COVID related labor, heat dome and irrigation.

Crosses made in 2018 were planted at the WSU Goss Farm in 2019 and 69 selections were made in summer 2021. The crosses emphasized parents that are machine harvestable and root rot resistant. Of the current year selections, 27% were derived from WSU 2130, 23% from 'Cascade Premier', and 22% from WSU 2162. Tips of these selections were collected for establishment in tissue culture and propagation for the next stage of testing in the machine harvesting trial. The new selections were also dug for maintenance as stock plants and virus testing.

Machine Harvesting Trials. A new machine harvesting trial was planted in 2021 at Randy Honcoop's farm. Two machine-harvesting trials were maintained and evaluated for yield and fruit quality in 2021, as indicated in the table below. A third trial was established.

Establish-ment year	Number of selections	Achievements
2018	47 and 3 cultivars	Maintained; evaluated selections for the second season for fruit quality and yield to drive advancement and discard decisions.
2019	47 and 3 cultivars	Maintained; evaluated selections for the first season for fruit quality and yield to drive advancement and discard decisions.
2020	0	Postponed/selections held for a new planting for 2021.
2021	84 and 3 cultivars	Prepared, planted and maintained

After two years of observational yield and fruit quality evaluation in the 2018 MH trial, the following selections will be advancing for further evaluations for yield and fruit quality:

- WSU 2205. Good yield, early season, medium size, good firmness, machines well, pretty good integrity – some breaking seen.
- WSU 2234. High yield, early, large, firm, rich red color, machines well, good integrity.

- WSU 2372. Very large size, very high yield, early season. Machines well. Some crumbly fruit seen at Enfields, not known whether this a result of tissue culture.
- WSU 2407. Very large size, high yield, early season. Machines well.
- WSU 2425. Medium size. Very high yield, early-mid season. Machines well.

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

Selection	Grower Trial Stage	Description
WSU 2130	425 plants, 2020-2023, 4 grower sites	Very high yielding in Puyallup, North Willamette, and Enfields over two harvest seasons. Early ripening season, similar to 'Willamette', with firm, medium sized fruit.
WSU 2068	50 plants, 2020-2023, 1 grower site. 100 plants, 2018-2022, 2 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.
WSU 2069	50 plants, 2020-2023, 1 grower site. 100 plants, 2018-2022, 2 grower sites	High yielding, early season selection, large berries with good firmness. Somewhat tolerant to root rot.
WSU 2088	425 plants, 2020-2023, 4 grower sites	High yields at WSU Puyallup; high yield, and excellent firmness in nonreplicated grower trial compared with 'Wakefield'. Overall dark color berries of medium size. Late season selection.
WSU 2087	150 plants, 2020-2023, 1 grower site. 50	Two year yields similar to 'Wakefield'. Berries are firm, firmer than 'Meeker'. This is a mid-late season selection, with a midpoint of harvest season 2 days after 'Meeker'. Root rot tolerant.

Yield and Fruit Quality Evaluations (selection trials). We have discontinued replicated trials in Puyallup planted 2017-2020 and have focused our efforts to plant replicated yield trials in Whatcom County with grower cooperators.

Establish-ment year	Number of selections	Tasks and plans
2021	18 and 3 cultivars	Established in 2021 for first evaluation in 2023 by machine, sampling the baby crops for fruit chemistry traits in 2022.

The Small Fruit Plant Breeding program is increasing the collaborative activities with Lisa DeVetter's Small Fruit Horticulture program for the trials in Whatcom Co. This cooperation is expected to yield high quality data from machine harvesting and fruit quality evaluations. It also establishes a valuable "showcase" of advanced WSU germplasm at WSU Mount Vernon to increase visibility to the raspberry industry and for a prospective faculty plant breeder as the hiring process progresses.

Root rot evaluations. The Goss Farm is known for high levels of root rot and is an ideal field to screen selections for their tolerance to *Phytophthora* root rot. Five plantings are currently being maintained and evaluated at WSU Puyallup as indicated by the table below. Each planting contains single-plant plots in four replicates. Results are included in Tables 1-2.

Establish-ment year	Number of selections	Tasks and highlights
2017	29, 8 cvs	Maintained; evaluated selections for root rot tolerance, planting slated for removal in late winter. WSU 2298 and WSU 2069 performed well in this planting.
2018	26, 3 cvs	Maintained; evaluated selections for 2nd time for root rot tolerance. WSU 2442, WSU 2234, and WSU 2376 performed well for root rot tolerance from this planting.
2019	27, 4 cvs	Maintained; evaluated selections for 1st time for establishment. WSU 2516 and WSU 2605 established fairly well in this planting, which is a reflection of plug quality, plant vigor, and root rot tolerance.
2020	20, 4 cvs	Established this root rot planting for first evaluation in 2021.
2021	21, 3 cvs	Established this root rot planting for first evaluation in 2022.

Publications/Presentations

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

Tables

Table 1. Root rot tolerance of WSU selections and standard cultivars evaluated in th over three years after establishment in 2017.

Selection	Rating 2021[z]		Rating 2020		Rating 2018	
WSU 2298	5.0	A[y]	5.0	a	4.5	abc
Hall's Beauty	4.5	a	4.3	ab	4.8	ab
Columbia Giant	4.0	ab	4.3	ab	3.3	abcde
ORUS 4289-4	3.8	abc	4.3	ab	5.0	a
Columbia Sunrise	3.8	abc	3.5	abcd	4.0	abc
ORUS 4857-1	3.5	abcd	3.5	abcd	4.5	abc
Columbia Star	3.3	abcde	3.8	abc	4.0	abc
ORUS 3219-2	3.0	abcdef	3.8	abc	2.0	abcde
ORUS 3021-1	3.0	abcdef	3.0	abcde	1.8	abcde
Black Diamond	2.8	abcdefg	3.8	abc[y]	3.8	abcd
WSU 2377	2.5	abcdefg	3.3	abcde	3.5	abcd
WSU 2069	2.5	abcdefg	3.3	abcde	3.0	abcde
ORUS 3409-1	2.5	abcdefg	2.8	abcde	2.0	abcde
WSU 2123	1.5	bcdefg	1.8	abcde	2.8	abcde
WSU 2363	1.3	bcdefg	2.3	abcde	2.0	abcde
ORUS 5005-2	1.0	cdefg	1.3	bcde	2.3	abcde
ORUS 4465-3	1.0	cdefg	1.8	abcde	3.5	abcd

WSU 1962	0.8	defg	1.0	bcde	3.5	abcd
ORUS 4715-3	0.8	defg	1.8	abcde	3.8	abcd
Meeker	0.8	defg	1.5	bcde	3.5	abcd
Cascade Harvest	0.8	defg	2.0	abcde	4.0	abc
WSU 2366	0.5	efg	0.3	de	2.3	abcde
WSU 2068	0.5	efg	0.0	e	2.3	abcde
ORUS 4722-2	0.5	efg	0.5	cde	2.0	abcde
ORUS 4291-1	0.5	efg	0.0	e	0.5	de
ORUS 1154R-3	0.5	efg	0.8	cde	3.5	abcd
WSU 2278	0.3	fg	1.3	bcde	1.5	bcde
WSU 2190	0.3	fg	0.8	cde	2.5	abcde
ORUS 4988-1	0.3	fg	1.8	abcde	4.3	abc
ORUS 4856-1	0.3	fg	1.0	bcde	3.3	abcde
WSU 2162	0.0	g	0.0	e	2.5	abcde
ORUS 5004-4	0.0	g	0.3	de	2.0	abcde
ORUS 4988-3	0.0	g	0.8	cde	2.5	abcde
ORUS 4864-1	0.0	g	0.0	e	1.3	cde
ORUS 4722-1	0.0	g	0.0	e	0.0	e
ORUS 4716-2	0.0	g	0.8	cde	2.0	abcde
Kokanee	0.0	g	0.5	Cde	2.8	abcde

[z]Rating was at a scale 0-5, where 0 = dead plant; 5= vigorous, thriving.

[y]Ratings within a column followed by the same letter are not significantly different at $P<0.05$.

Table 2. Root rot tolerance of WSU and ORUS selections and standard cultivars evaluated in two years after establishment in 2019.

Selection	Establishment Rating 2020[z]	Rating 2021[y]	
ORUS 4545-2	3.5	4.75	a
Twilight	2.8	4.25	ab
ORUS 3381-3	2.5	3.75	ab
ORUS 5094-1	2.8	3.5	ab
ORUS 3021-2	3.8	3.25	ab
Willamette	3.3	3.25	ab
Meeker	2.3	3	ab
WSU 2162	2.8	3	ab
ORUS 4412-2	2.5	2.75	ab
ORUS 5106-1	1.5	2.75	ab
WSU 2516	2.3	2.5	ab
ORUS 5094-2	1.3	2.25	ab
ORUS 4487-1	2.0	2	ab
ORUS 4535-1	1.0	2	ab
ORUS 4716-1	2.3	2	ab
ORUS 4870-2	1.8	2	ab
ORUS 5104-2	2.8	2	ab

ORUS 5106-3	0.8	2	ab
WSU 2605	2.3	2	ab
Cascade Harvest	1.5	1.75	ab
WSU 2277	1.3	1.75	ab
ORUS 4222-1	1.8	1.5	ab
ORUS 4959-1	2.3	1.5	ab
ORUS 4965-3	1.0	1.25	ab
ORUS 3032-3	1.0	1	ab
ORUS 4693-2	0.8	1	ab
ORUS 4985-1	1.5	1	ab
ORUS 4858-2	1.8	0.75	ab
WSU 2363	1.5	0.5	ab
ORUS 4974-1	1.8	0	b
WSU 2481	1.0	0	b

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

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

2022 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

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

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

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

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

Project Request: $ 87,701

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

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

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

Description: The program will develop new red raspberry cultivars for use by commercial growers in the Pacific Northwest, with emphasis on new cultivars with high yield, machine harvestability, root rot tolerance 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 tolerance, and fruit quality, including firmness, color, flavor, and size. Selections will be evaluated for adaptation to machine harvestability by planting selections with cooperating growers. Promising selections will be propagated for grower trials, leveraging grower trial data toward cultivar release decisions.

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

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

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

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

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

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

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

Results will be transferred through regular meetings with the WRRC, field days, Small Fruit Update newsletters, and grower conferences.

Procedures

1. Crosses (0^{th} stage). PREC. Cross parents likely to produce progeny with excellent traits. Status: Planned for Spring 2022.
2. Seedlings (1st stage). PREC. Germinate seeds from crosses, plant, grow for 2 years and identify excellent individuals (selections) to enter cultivar development pipeline. Status: 2021 crosses developing for planting 2022; 2023 planting location being negotiated with Whatcom growers.
3. Machine harvest (MH) trial (2nd stage). Lynden. New selections are propagated and test in second stage trial for machine harvestability, yield, and fruit quality. Status: 2019 MH trial maintained for evaluation 2022; 2021 MH trial maintained for eval 2023; 2022 planting being prepped for planting in spring.
4. Replicated Yield Trial (3rd stage). Lynden. Selections that have performed well in the observational MH trial are evaluated in replicated plots for yield and fruit quality. Status: 2021 rep trial maintained; 2022 planting to be planted in spring.
5. Root rot trial (4th stage). PREC. Root rot response is evaluated in comparison with standard cultivars for 3 years. Status: Root rot plots planted in 2019, 2020, and 2021 will be maintained and evaluated for tolerance in 2022.
6. Regional replicated trials (Adv stage). Dossett/BC, Hardigan/OR. Selections from 3rd Stage are evaluated in replicated plots for yield and fruit quality across growing environments. WRRC funding supports propagation and transport of WSU material, but all costs of planting and evaluation are borne by other programs.
7. Grower Trials (Adv stage). Walters, Pond/NBF. Three to four elite selections are propagated by nursery then tested by growers to assess for yield, fruit quality, and traits important to commercial production, like establishment, water use, diseases, 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, 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		2021-2022
Salaries - 00		$ 22,752
Plant Technician (0.50 FTE)	$ 22,752	
Time-slip Wages - 01		$ 29,400
Goods/Services - 03		$ 19,000
Machine harvest trials, including rep. yld trial	$ 12,000	
Land use fees	$ 2,000	
Supplies	$ 5,000	
Travel - 04		$ 1,239
Benefits - 07		$ 15,310
Total Direct Costs		**$ 87,701**

Budget Justification

Salaries and Wages:
Plant Technician. Plant Tech 3 Pugh will prepare and till fields, maintain equipment, design and plant plots, scout and treat pest problems, prune, trellis, do other plot maintenance, and supervise temporary employees. This equates to 0.5 FTE ($22,752).
Non-student temporary worker. A temporary worker will conduct tissue culture and greenhouse propagation, at a wage of $20/hr for 15 hrs/week for 50 weeks ($15,000)
Student and temporary worker. Seasonal workers will harvest fruit, collect data under supervision of PIs, maintain plots, and do field work. This includes timeslip help to collect data at grower field in MH trial. This equates to 960 hours at $15/hr ($14,400).

Benefits. Plant Technician benefits are $12,370 for 0.5 FTE. Temporary employee benefits amount to $2,940.

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 $12,000.
Land use fees. WSU farm services fees for seedling, selection, and germplasm plantings amount to 20 acres at $100/acre ($2,000).
Supplies. Crop protection products, fertilizers, potting media and containers, irrigation equipment, greenhouse electricity, harvest equipment and consumables, and laboratory reagents and consumables will be needed to conduct this work ($5,000).

Travel. Travel for the project, including to visit trial plots, meet with collaborators, and present results are estimated to be 5 trips between Puyallup and Lynden (round trip and local = 300 miles x $.56/mile x 5 trips) in one year, and 7 trips between Mount Vernon and Lynden (round trip and local =102 miles x $0.56/mile x 7 trips = ~$1,239).

Current Support

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

Pending Support

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

Project No: Walters 2021 Plant Breeding Contract #7

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

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

Reporting Period: Jan 1 2021-Dec 31 2021

Accomplishments:

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

Results:
WSU 2166 (Cascade Premier). Trialed 2 locations 2017, 1 location 2018, 2 commercial fields. Excellent bud break, even alongside winter-damaged 'Meeker'. Bloom comes early, as does fruit expansion. Very large, relatively few (typically 10-13) fruits per long lateral. Susceptible to cane Botrytis, yield limiting in some cases. Excellent root rot resistance, multiple locations. Harvests well, can IQF when harvest interval is <3 days.

WSU 2188 Trialed 2 locations 2017, 2 locations 2020, 2 locations 2021. Large, droopy-looking plants, long leaves. Good winter hardiness, excellent budbreak. Bloom time sim Meeker. Fruiting laterals shorter than those of Cascade Premier. More fruit per lateral, 18-25. Aggressive primocane growth. At one location, lost a lot of buds to cane Botrytis, similar to Cascade Premier. Likely release 2022-2023.

WSU 2010, WSU 2162, WSU 1914. Trialed 1-2 locations 2017. Moderate root rot resistance. Drop.

WSU 1962 Trialed 2 locations 2018. Canes few, thick, but lots of fruit per cane. Large plants, dense canopy tends to generate a bit more fruit mold. Late to flower, continues to flower and fruit well past Meeker season. Good-flavored, firm fruit. No obvious root rot problem but looks better on higher ground. Drop for processing. Fresh market potential?

WSU 2068 Trialed 2 locations 2018, one location 2020. Very good winter hardiness. Early fruiting, full canopy, firm, good yield, good flavor.

WSU 2069 Trialed 2 locations 2018, one location 2020. Also very good winter hardiness, and early, like WSU 2068. Flavor not quite as good as 2068. Canes white with cane Botrytis at one location. Root rot tolerance also not quite up to the level of 2068. In the 2020 trial, more ripe fruit than 2068, long harvest season.

WSU 2088 Trialed 4 locations 2020. Many fruits per lateral, long fruiting season. Short-statured, smaller than 2130. Fruit seems to be good quality in the first season.

WSU 2130 Trialed 4 locations 2020. Good winter hardiness. Red laterals. Good amount of attractive, conic fruit across the canopy, looked promising in June, but hard hit by heat damage late that month. Small plant without much fruit at a heavy root rot site.

Publications: Information submitted to Northwest Berry Foundation for inclusion in the Small Fruit Update; presentation to be made at Northwest Berry Conference.

2022 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

Project Proposal **Proposed Duration:** 2 years

Project Title: On-farm Trials of Advanced Raspberry Selections

PI:
Tom Walters
Owner, Walters Ag Research
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Anacortes WA 98221

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

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

Year Initiated_2022_ Current Year_2022 Terminating Year_2023_

Total Project Request: 2022 $5,128 **2023: $5,928**

Other funding sources:

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

Description

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

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

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

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

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

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

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

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

Objectives:
In 2022, we will:
- Make third year (full crop) evaluations on the three spring-planted 2020 trials.
- Make second year (baby crop) evaluations on the fall-planted 2020 trial, as well as spring-planted trials of WSU 2188 (two plantings, 2-4 A each), and WSU 2087
- Develop list of selections to be included in onfarm trials in future years and coordinate with Northwest Plant Co for their propagation.
- Disseminate coordinated information from BC, WA and OR trials to growers

Procedures:

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

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

One grower has prepared for field-scale (4A) evaluation of WSU 2188, which will be planted Spring 2021. This planting is large enough to evaluate fruit in an IQF tunnel in 2022 and 2023. These evaluations will be critical to the decision whether to release this selection. Northwest Plant Company indicates that adequate plant numbers should be available for this trial by Spring 2021. Fruit quality in this trial will be evaluated in 2022 and 2023.

Project guidelines

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

Grower/cooperator arrangements

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

Anticipated Benefits and Information Transfer:

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

Budget

	2022	2023
Salaries[1/]	**$3,000**	$3,000
Travel[2/]	**403**	$403
Outreach[3/] `	**1,500**	$1,500
Other (Propagator payments**)**[4/]	**0**	$ 800
Offices costs (to NBF**)**	**225**	$ 225
Total	**$5,128**	$5,928

Budget Justification

[1/] **Salaries**

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

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

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

[3/]**Outreach**

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

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

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

Office costs (overhead, to NBF) $225

Project Report **Proposed Duration:** 1 year

Project Title: An Economic Fingerprinting Set for Red Raspberry

PI: Jason Zurn
Organization: USDA-ARS-NCGR
Title: Postdoctoral Fellow
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Email:Jason.zurn@ usda.gov
Address: 33447 Peoria Rd
Address 2:
City/State/Zip: Corvallis, OR 97333

Co-PI: Nahla Bassil
Organization: USDA-ARS-NCGR
Title: Plant Geneticist
Phone: 541-738-4214
Email:Nahla.bassil@ars.usda.gov
Address: 33447 Peoria Rd.
Address 2:
City/State/Zip: Corvallis, OR 97333

Cooperators: Chad Finn, Michael Dossett, Michael Hardigan
Amount awarded: $6,550
Project initiated: 2019
Objectives:

1) Develop a robust Next Generation Sequencing-based DNA fingerprinting set capable of characterizing hundreds of cultivars at thousands of genetic locations
2) Develop a rapid SSR-based fingerprinting set for quick use at a few highly variable loci
3) Create a catalog of genetic profiles for important cultivars grown in the Pacific Northwest and their relatives

Accomplishments

- We determined that rhAmpSeq was the best option for germplasm identification by allowing us to evaluate simple sequence repeat (SSR), insertion/deletion (INDEL), and single nucleotide polymorphisms (SNPs) in a single platform.
- We aligned sequencing data from red and black raspberry sequencing data from 12 studies to the black raspberry version 3 reference genome and identified 126,616 SSRs and 9,717,410 sequence variants (SNPs and INDELs).
- Of 1,995 genetic regions of interest for assay design, we selected 1,000 primer pairs that were evenly distributed across the black raspberry reference genome and used them to genotype 384 red and black raspberry samples from the USDA-ARS National Clonal Germplasm Repository in Corvallis, OR.
- rhAmpSeq amplicon sequences were aligned to the *Rubus occidentalis* v3 genome assembly and used to predict SNP and indel (including SSR) variant sites.
- Ninety-two SSR loci were identified among the indel calls in the sequenced regions and analyzed across genotypes for diversity, repeat length, and allele number. Sequences flanking SSR loci were used to design PCR primer sequences for testing.
- Estimated red raspberry and black raspberry heterozygosity/diversity at variant sites to predict their efficacy for distinguishing germplasm and cultivars (fingerprinting).
- Used diversity estimates to select a set of 48 SNP variant sites as candidate fingerprinting assays and submitted to company LGC for conversion into KASP assays.

Results

- After quality filtering, identified a total 1,840 SNP and indel variants as potential candidates for marker fingerprinting assays, including KASP and SSRs.
- Identified 92 potential SSR-type variants within the 1,840 total variants.
- Received results from 48 SNP KASP assay designs from LGC.
- Of the 92 SSR sequences analyzed, 28 meet the criteria of having a repeat motif of at least 3 base pairs and also have a high degree of variability in the panel of North American and European red raspberry germplasm.

Outstanding Work

Restrictions implemented due to the COVID19 pandemic have limited the pace of certain lab work associated with the project. The following work needs to be completed to finish the project and ensure that its outputs will be useable for the community. We anticipate that this will be completed in the next several months

- Validate amplification and scoreability of the identified SSRs in single- and multiplex PCR reactions for use as a fingerprinting set. This will start with the 28 SSRs identified as having the highest potential to meet project objectives as indicated above, but will be expanded to include additional loci if needed.
- Analyze LGC KASP data for 48 submitted SNP variants to determine whether they are working properly, and their ability to distinguish raspberry germplasm and replace loci that failed with working assays and repeat the genotyping.

Publications

None so far

Washington Red Raspberry Commission
Progress Report Format for 2021 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: 2021

Accomplishments:

- In 2021, we established ~5100 new seedlings in the field from 2020 crosses and established a new yield trial which includes replicated plots of the first round of selections to come from our seedlings grown on farm by cooperating growers. We also evaluated ~11,000 seedlings in the field and made 103 new selections.

- In 2021 we machine harvested approximately 6.5 acres of trial plots at the Clearbrook station, including seedlings from 2017 and 2018 crosses and yield trials planted in 2018 and 2019. Data collected from all of these include plot yield, average fruit size, and ratings of machine-harvest tray quality. Select samples have been saved for further analysis of fruit chemistry at a later date. This also includes 4 acres of trials geared towards studying heritability and correlations of yield, yield components, and fruit phenology to tackle strategies for selecting for higher yield and early ripening.

Results:

- Two things significantly impacted the 2021 crop. First, there as significant winter injury in some genotypes and crosses. This manifested itself with weak and spotty lateral growth in these genotypes. Meeker was among the more significantly impacted from winter injury at Clearbrook. A warm dry spring pushed lateral development such that some marginal genotypes were not able to recover lateral strength before bloom, and laterals were shorter with fewer berries on average than in 2020. Second the heat dome in late June had a significant impact on things. Some genotypes showed a lot of damage from the heat. Nearly everything that was producing during the heat dome was impacted very hard. Later ripening genotypes showed a range of damage from significant to no apparent injury.

- Because of the difficulty in determining how best to account for the above impacts, yield measurements from 2021 are being given less weight in evaluations this year and plot evaluation were based more strongly on ratings of crop load and assessment of machine-harvest quality in the tray. After working through harvests with sunburned fruit from the heat dome, tray quality overall was very good for most of the remainder of the season (albeit with smaller fruit), however some genotypes definitely stood out as exceptional.

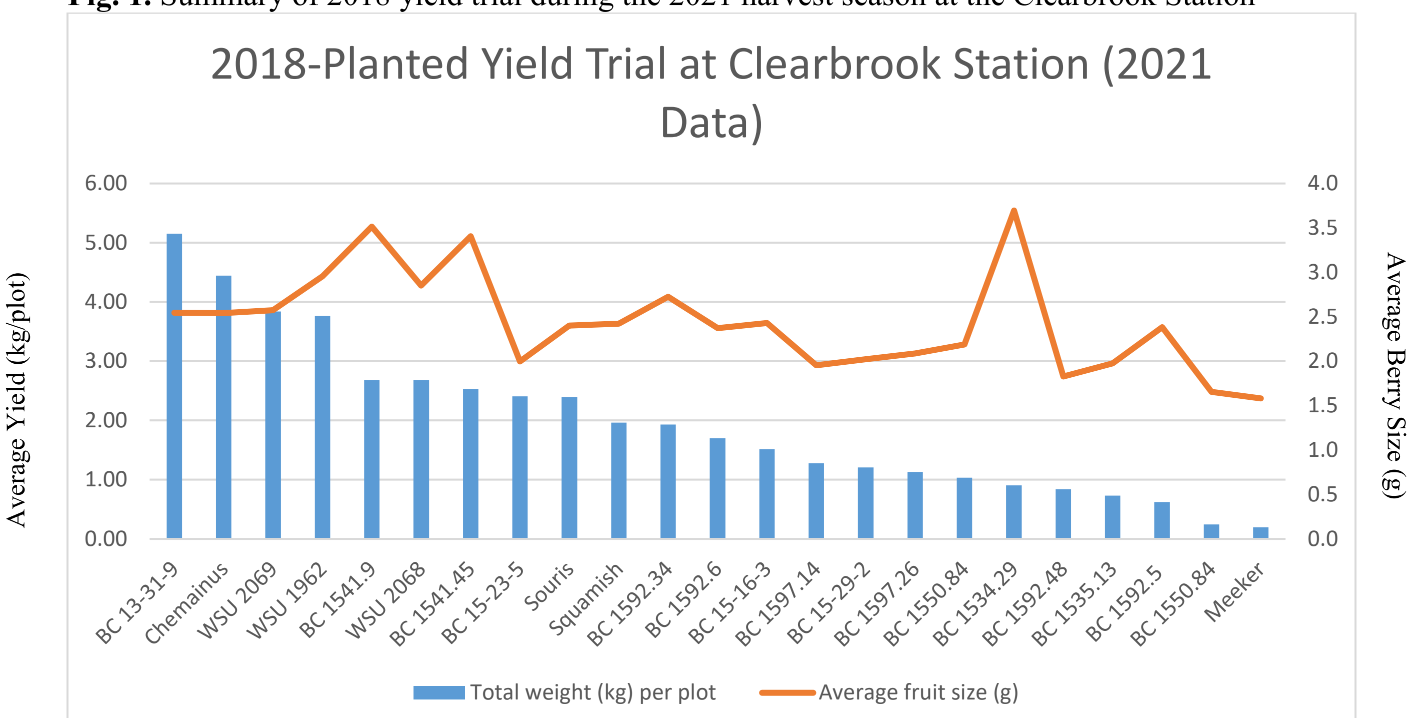
- In the 2021 season, BC 13-31-9 was the top yielding genotype in the 2018 yield trial (second highest in 2020, just behind WSU 2069) followed by Chemainus and WSU 2069. Overall, their yields were about half of what they were in 2020, with berry size across the season being about 70% of last year. 2018 yield trial results are summarized below (Fig 1).

- In the 2019 yield trial, BC 1543.53 had the highest yield, was mostly unfazed by the heat dome (first berries just starting to ripen when heat hit), had good tray quality, and was a beast of a plant with excellent vigor in the primocanes for next year's crop. BC 15-53-15, and BC 15-53-3 had exceptional tray quality, strong yields and good primocane vigor for next year. These are three are being propagated so that ~500 plants can go out to growers in 2022 to get a bit of a broader look at them. 2019 yield trial data and other data are not displayed here in the interest of space and having them display properly on this paper size but interested parties can contact me for electronic versions.

Publications:

- Aside from reports to funding agencies and stakeholders, there were no publications in 2021, though data from the yield components and heritability analysis are being prepared for publication

Fig. 1. Summary of 2018 yield trial during the 2021 harvest season at the Clearbrook Station



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 of their time must be listed whether or not salary for the person(s) involved is included in the budgets of the various projects.
3. Provide analogous information for all proposed research which is being considered by, or which will be submitted in the near future to, other possible sponsors.

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
	Current:				
	AAFC, BCBC, WBC, LMHIA	$1,694,948	April 1, 2018 – March 31, 2023	55%	Blueberry Germplasm and Cultivar Development for the Pacific Northwest
	AAFC, WRRC, RIDC, LMHIA	$1,232,690	April 1, 2018 – March 31, 2023	40%	Red Raspberry Germplasm and Cultivar Development for the Pacific Northwest
	AAFC, WSC, BCSGA, LMHIA	$154,086	April 1, 2018 – March 31, 2023	5%	Strawberry Germplasm and Cultivar Development for the Pacific Northwest
	Pending:				

2022 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

New Project Proposal **Proposed Duration:** (1 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
(please note, Michael.Dossett@agr.gc.ca is no longer in use)
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 2022 **Current Year** 2022 **Terminating Year** 2022

Total Project Request: **Year 1: $10,000** **Year 2 $** **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: 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/Awarded: *(retain either requested or awarded and delete the other)*
Notes: We have received approval of our 5-year proposal from the federal government (April 2018- March 2023). We have also received a commitment from the Province of BC to help support our efforts. Our overall funding for the program was approved at a 60:40 federal:industry matching ratio with the raspberry portion valued at ~$236k annually. Our overall costs have gone up because of a lower matching ratio from past years (previously was 75:25), the need to replace technical support that was provided by Agriculture Canada in the previous policy framework and which is no longer being provided to the program, and the implementation of rental fees for our access to AAFC facilities and land. We have sought in-kind support from some of our growers, Littau harvester, and other sources, which we have been able to leverage towards the receipt of federal funds. After all sources except for the RIDC are accounted for, the outstanding cash portion of the raspberry breeding effort is valued at $59,376, the bulk of which will be covered by the RIDC, the funding we are asking for from the Washington Red Raspberry Commission will be used to help offset this amount, specifically to help hire summer labor for planting, harvest, and field care. We are asking for funding in 2022 as the final year of our five-year funding cycle, as our overall budgets and matching ratios will change in 2023 for the next cycle.

Description: This project is to support the continued effort to breed raspberry cultivars adapted to the PNW. Breeding for disease and insect resistance, yield, and fruit quality is the most sustainable way to address industry needs and ensure long-term competitiveness. We will continue to cross and select from a diverse gene pool and evaluate previous selections with the following specific objectives:

- Develop red raspberry cultivars and elite germplasm, stressing suitability for machine harvest, fruit quality, as well as resistance to root rot, RBDV and other diseases
- Develop red raspberry cultivars and elite germplasm that is suitable for machine harvesting and produces high yields of superior fruit quality and fruit rot resistance.
- Identify and select raspberries with dark red fruit for processing that also exhibit characteristics that are suited for IQF processing
- Identify and incorporate new sources of resistance to aphids, spider mites, and other insect pests.
- Continue development and testing of molecular tools to speed up the process of selecting and identifying parents and seedlings in the program with durable disease resistance and outstanding quality traits.

Justification and Background:
The red raspberry industry is facing challenges with diseases, increased production costs and competition from the global marketplace. 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 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. 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. Historically, one of the difficulties we have encountered is that our material with a high degree of root rot tolerance has not been machine-harvestable and has been a bit soft. This shift in focus has enabled us to more quickly identify germplasm that has good machine harvest quality and cycle it to use as a parent for future generations. The first selections resulting from this strategy are now in replicated trials and the percentage of new selections in the program that harvest with good quality has grown exponentially over the last few years. We 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. 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:
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 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.

A specific part of this project with more definite timelines is the development and evaluation of molecular genetics tools to identify markers for insect and disease resistance as well as other traits. The first stage of this work (marker identification) has begun. We are currently in the process of screening markers in two populations that segregate for different sources of root rot resistance, a newly identified source of RBDV resistance, and three sources of aphid resistance (one broken, two unbroken). Basic linkage maps are essentially complete, but we are actively adding markers to these maps to increase their resolution and the ability to identify markers tightly linked to traits of interest. Testing for RBDV infection will be an ongoing process, and we are currently in the process of validating two potential markers for RBDV resistance in this population as well as their transferability to our overall germplasm.

Anticipated Benefits and Information Transfer:
Specific benefits that will result from this project include:

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

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

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

	2022	2023	2024
Salaries[1/]	$	$	$
Time-Slip	$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. See note above regarding matching ratios and how these fit into the overall picture. This is the final year of our 5-year funding framework with the government of Canada, with the current funding cycle ending March 31, 2023.

ENTOMOLOGY

Project Title: Developing New Miticides on Raspberry

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

Cooperators: Tom Walters, Walters Ag Research

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

Other Funding Sources: This project was also supported by a grant from the Washington State Commission on Pesticide Registration.

Materials and Methods

Research staff at Agriculture Development Group, Inc. conducted a research trial investigating the efficacy of 13 products for control of two-spotted spider mite (TSSM) in raspberry. The trial location was just east of Lynden WA (Whatcom County). The experimental design for this trial was a RCB with 4 replications and plot sizes of 10ft x 25ft. Applications for this trial were made with an over-the-row sprayer calibrated to apply treatment sprays at 85 gallons per acre (Photo 1).

Two applications were made on 8/5 (A) and again 5 days later on 8/10 (B). To assess the mite population, 20 leaves per plot were collected and at 8/10, 8/19, 8/25, and 9/3, and the mites were collected from the leaves using a mite-brush and counted under microscope (Photo 2). The data was then transferred to # of TSSM per leaf. The application was started relatively late as the trial was placed in a commercial raspberry field and the applications could not start until harvest was complete to make sure no off label residues were on harvested fruit. The grower cooperator would not allow unregistered products to be applied in his field until after harvest. Mites were present at above action threshold levels at the first sampling immediately after harvest.

Table 1. Treatment list with application codes.

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

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

Overall, the TSSM eggs exhibited higher susceptibility to the treatmentsas compared to nymph and adult.

At August 5th although not statistically significant, the data showed obvious lower than untreated check egg counts as compared FujiMite, Kanemite, and Savey with 32.8, 12.3, and 11.8 eggs respectively (Table 2), suggesting 32%, 74%, and 75% control efficacy compared to 48 counts of untreated check. Kanemite is the only treatment that also exhibited a negative impact on mite nymphs and adults, with 5.5 nymphs and 6.5 adults, as compared to 8.8 nymphs and 13.3 adults in the untreated check.

Mite pressure dropped dramatically from 8/19 to 9/3 sampling dates, potentially caused by abnormal long period of high temperature weather. As a result, the overall study total egg, nymph, and adult data showed same trend as 8/10 data, where FujiMite, Kanemite, and Savey cumulatively had 34.5, 14.5, and 11.8 eggs respectively (Table 2; Figure 1), 29 to 76% reduction compared to 48.3 total eggs of untreated check. Again, only Kanemite had numerically lower than untreated total nymphs (18.3) and adults (7.8).

In summary, results suggest a potential of FujiMite, Kanemite, and Savey for controlling TSSM eggs, while Kanemite showed slight advantage on control of nymphs and adults as well. Some of ther tested products increased TSSM populations as compared to theuntreated check.   This is particularly true for Brigade (bifenthrin) which has nearly an order of magnitude higher numbers of mite adults, eggs and nymphs as compared to the untreated check.   In future work, it is critical that applications start at the beginning of the outbreak and not after mite numbers reached peak numbers as happened in 2021.

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

Pest Name					Two-spotted spi>	Two-spotted spi>	Two-spotted spi>	Two-spotted spi>	Two-spotted spi>
Crop Name					red raspberry	red raspberry	red raspberry	red raspberry	red raspberry
Rating Date					8/10/2021	8/10/2021	8/10/2021	8/19/2021	8/19/2021
Rating Type					Egg	Nymph	Adult	Egg	Nymph
Rating Unit/Min/Max					COUNT, -, -	COUNT, -, -	COUNT, -, -	COUNT, -, -	COUNT, -, -
Sample Size					20 leaves	20 leaves	20 leaves	20 leaves	20 leaves
Days After First/Last Applic.					9, 5	9, 5	9, 5	18, 14	18, 14
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	1*	2*	3*	4*	5*
1	Untreated Check				48.0a	8.8a	13.3a	0.3a	4.5a
2	FujiMite SC	2	pt/a	B	32.8a	19.0a	10.8a	1.5a	7.0a
3	Kanemite 15 SC	31	fl oz/a	B	12.3a	5.5a	6.5a	1.8a	6.3a
4	Aza-Direct	3	pt/a	B	95.3a	21.8a	31.5a	0.5a	6.5a
5	Savey 50 DF	6	oz/a	A	11.8a	21.3a	36.0a	0.0a	5.5a
6	Acramite 50 WS	1	lb/a	B	134.5a	58.3a	75.5a	0.5a	5.3a
7	Agri-Mek	4	fl oz/a	B	152.8a	105.0a	53.0a	1.0a	6.0a
8	Brigade 2 EC	6.4	fl oz/a	B	602.3a	72.8a	65.8a	0.5a	7.8a
9	Danitol 2.4 EC	16	fl oz/a	B	94.8a	79.3a	50.3a	1.0a	4.5a
10	Oberon 2SC	16	fl oz/a	B	51.5a	36.5a	61.5a	1.5a	4.8a
11	Nealta	13.7	fl oz/a	B	91.5a	49.0a	79.5a	1.5a	5.3a
12	Zeal	3	oz/a	B	235.5a	40.3a	54.5a	0.0a	7.8a
13	Asana	4.8	fl oz/a	B	72.5a	65.0a	38.5a	2.0a	8.0a
LSD P=.05					498.20	104.86	67.83	1.84	5.73
Treatment F					0.806	0.679	1.038	1.125	0.393
Treatment Prob(F)					0.6422	0.7601	0.4371	0.3715	0.9573

Pest Name					Two-spotted spi>	Two-spotted spi>	Two-spotted spi>	Two-spotted spi>	Two-spotted spi>
Crop Name					red raspberry	red raspberry	red raspberry	red raspberry	red raspberry
Rating Date					8/19/2021	8/25/2021	8/25/2021	8/25/2021	9/3/2021
Rating Type					Adult	Egg	Nymph	Adult	Egg
Rating Unit/Min/Max					COUNT, -, -	COUNT, -, -	COUNT, -, -	COUNT, -, -	COUNT, -, -
Sample Size					20 leaves	20 leaves	20 leaves	20 leaves	20 leaves
Days After First/Last Applic.					18, 14	24, 20	24, 20	24, 20	33, 29
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	6*	7*	8*	9*	10*
1	Untreated Check				1.0a	0.0a	6.3a	0.0a	0.0a
2	FujiMite SC	2	pt/a	B	0.5a	0.3a	6.8a	0.5a	0.0a
3	Kanemite 15 SC	31	fl oz/a	B	0.5a	0.5a	6.0a	0.0a	0.0a
4	Aza-Direct	3	pt/a	B	0.0a	0.0a	8.5a	0.0a	0.0a
5	Savey 50 DF	6	oz/a	A	0.0a	0.0a	2.3a	0.3a	0.0a
6	Acramite 50 WS	1	lb/a	B	0.3a	0.0a	6.0a	0.0a	0.0a
7	Agri-Mek	4	fl oz/a	B	0.0a	0.0a	3.8a	0.0a	0.0a
8	Brigade 2 EC	6.4	fl oz/a	B	0.0a	0.3a	8.8a	0.5a	0.0a
9	Danitol 2.4 EC	16	fl oz/a	B	0.5a	0.0a	7.8a	0.5a	0.0a
10	Oberon 2SC	16	fl oz/a	B	0.5a	0.0a	5.0a	0.3a	0.0a
11	Nealta	13.7	fl oz/a	B	0.3a	0.3a	5.3a	0.0a	0.0a
12	Zeal	3	oz/a	B	0.5a	0.5a	6.5a	0.8a	0.0a
13	Asana	4.8	fl oz/a	B	0.0a	0.0a	11.8a	2.0a	0.0a
LSD P=.05					1.16	0.66	6.89	1.69	.
Treatment F					0.586	0.716	0.986	0.892	0.000
Treatment Prob(F)					0.8386	0.7264	0.4801	0.5629	1.0000

Pest Name					Two-spotted spi>	Two-spotted spi>	Two-spotted spi>	Two-spotted spi>	Two-spotted spi>
Crop Name					red raspberry	red raspberry	red raspberry	red raspberry	red raspberry
Rating Date					9/3/2021	9/3/2021			
Rating Type					Nymph	Adult	Egg total	Nymph total	Adult total
Rating Unit/Min/Max					COUNT, -, -	COUNT, -, -			
Sample Size					20 leaves	20 leaves	20 leaves	20 leaves	20 leaves
Days After First/Last Applic.					33, 29	33, 29			
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	11*	12*	13*	14*	15*
1	Untreated Check				0.8a	0.0a	48.3a	20.3a	14.3a
2	FujiMite SC	2	pt/a	B	0.3a	0.3a	34.5a	33.0a	12.0a
3	Kanemite 15 SC	31	fl oz/a	B	0.5a	0.8a	14.5a	18.3a	7.8a
4	Aza-Direct	3	pt/a	B	0.3a	0.0a	95.8a	37.0a	31.5a
5	Savey 50 DF	6	oz/a	A	0.5a	0.3a	11.8a	29.5a	36.5a
6	Acramite 50 WS	1	lb/a	B	0.5a	0.5a	135.0a	70.0a	76.3a
7	Agri-Mek	4	fl oz/a	B	0.3a	0.5a	153.8a	115.0a	53.5a
8	Brigade 2 EC	6.4	fl oz/a	B	1.5a	0.8a	603.0a	90.8a	67.0a
9	Danitol 2.4 EC	16	fl oz/a	B	0.3a	0.0a	95.8a	91.8a	51.3a
10	Oberon 2SC	16	fl oz/a	B	1.5a	0.3a	53.0a	47.8a	62.5a
11	Nealta	13.7	fl oz/a	B	1.0a	0.0a	93.3a	60.5a	79.8a
12	Zeal	3	oz/a	B	1.8a	0.8a	236.0a	56.3a	56.5a
13	Asana	4.8	fl oz/a	B	0.8a	0.0a	74.5a	85.5a	40.5a
LSD P=.05					1.46	0.81	498.98	105.66	67.99
Treatment F					1.087	1.202	0.802	0.697	1.025
Treatment Prob(F)					0.3995	0.3190	0.6461	0.7431	0.4478

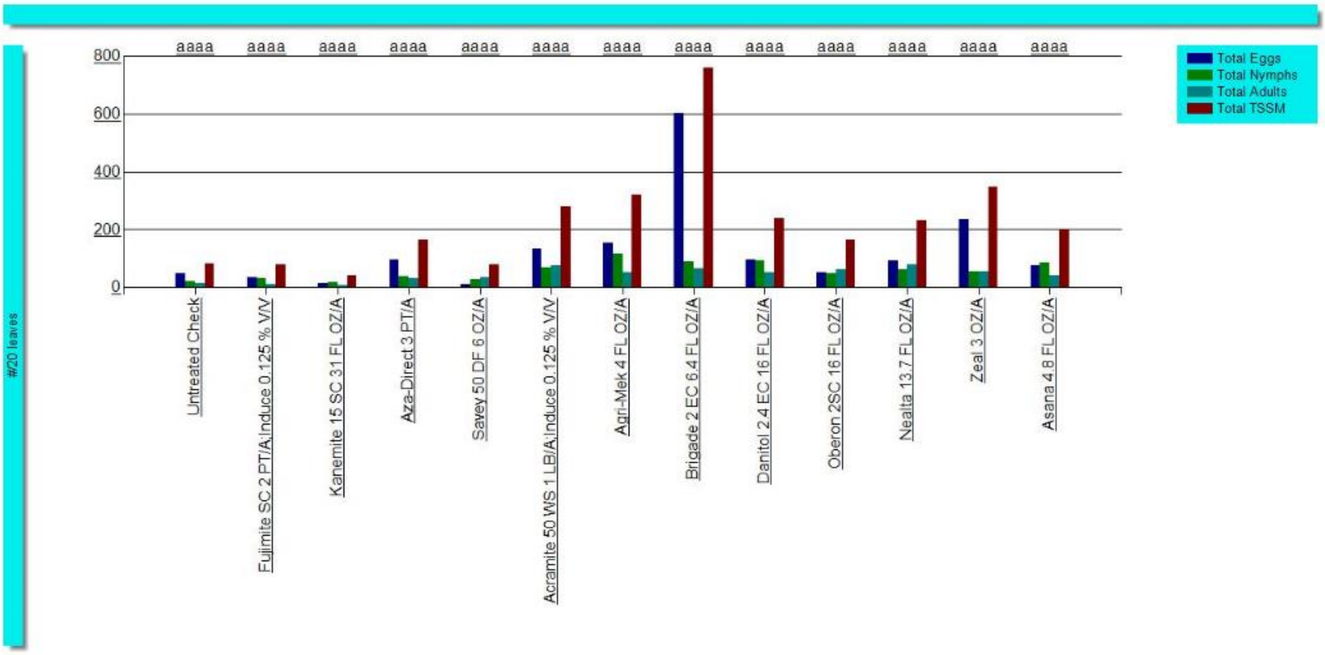
Pest Name				Two-spotted spi>
Crop Name				red raspberry
Rating Date				
Rating Type				All total
Rating Unit/Min/Max				
Sample Size				20 leaves
Days After First/Last Applic.				
Trt No. Treatment Name	Rate	Rate Unit	Appl Code	16*
1Untreated Check				82.8a
2FujiMite SC	2	pt/a	B	79.5a
3Kanemite 15 SC	31	fl oz/a	B	40.5a
4Aza-Direct	3	pt/a	B	164.3a
5Savey 50 DF	6	oz/a	A	77.8a
6Acramite 50 WS	1	lb/a	B	281.3a
7Agri-Mek	4	fl oz/a	B	322.3a
8Brigade 2 EC	6.4	fl oz/a	B	760.8a
9Danitol 2.4 EC	16	fl oz/a	B	238.8a
10Oberon 2SC	16	fl oz/a	B	163.3a
11Nealta	13.7	fl oz/a	B	233.5a
12Zeal	3	oz/a	B	348.8a
13Asana	4.8	fl oz/a	B	200.5a
LSD P=.05				611.72
Treatment F				0.770
Treatment Prob(F)				0.6764

Means followed by same letter or symbol do not significantly differ (P=.05, LSD).
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.
* Adjusted means
Could not calculate LSD (% mean diff) for columns 10 because error mean square = 0.
^Calculated from residual.

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

Photo 2. Mite assessment in the lab.

Figure 1. Treatment effect on TSSM total eggs, nymphs, and adults.



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

Project Title: Developing New Miticides on Raspberry

PI: Alan Schreiber
Organization: Agriculture Development Group, Inc.
Title: Researcher
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Cooperators: Tom Walters, Walters Ag Research

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

Total Project Request: Year 1 - $12,000 Year 2 - $12,495 Year 3 - $13,180

Other Funding Sources: We have submitted a proposal to the Washington State Commission on Pesticide Registration to support the WRRC effort in the amount of $12,955.

Justification and Background:

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

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

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

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

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

Objective 1. Collect information on two spotted spider mite biology – including a seasonal phenology on when mites first appear on raspberry to determine when first applications should begin.

Objective 2. Generate data on fungicide efficacy against two spotted spider mite.

Objective 3. Determine if Acramite resistance is present in two-spotted spider mite in Washington red raspberry.

Procedures:

<u>Biology Data</u>. We propose to collect data on mites from six fields with applications starting at the first detection of mites until one month after harvest. Raspberry leaves and weed leaves from the base of the plant will be collected from fields, packaged and shipped to ADG where they will be put through a mite brush and counted for each life stage by species of mite. A seasonal phenology for mites on raspberries will be constructed. Since yellow spider mite, McDaniels spider mite and European red mite have also been known as the pests of raspberries, mites will

be counted by species as well as life stages (eggs, larvae, nymphs and adults). Predatory mites such as *Neoseilulus fallacis* will be noted.

Efficacy Data. We propose to conduct a raspberry efficacy trial against TSSM. The trial would be placed in a field with detectable levels of mites with applications beginning just as mites are first detected on the leaves. Application would be 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 (Reaper), fenpyroximate (Fujimite), acequinocyl (Kanemite), azadiractin (Aza-Direct), bifenthrin (Brigade), fenpropathrin (Danitol), hexythiazox (Savey), bifenazate (Acramite) cyflumetofen (Nealta), etoxazole (Zeal), and spiromesifen (Oberon). The pyrethroids are being included to determine if their use flares mites as was demonstrated in WSCPR funded research on blueberries in 2020. Growers are interested in obtaining information about Nealta, a BASF product. BASF has expressed interest in allowing Nealta to be registered on raspberry via the IR-4 Project if sufficient positive efficacy data and lack of phytotoxicity data can be demonstrated. It is our hope that based on one to two years of efficacy data that BASF will allow this product to enter the IR-4 registration process. Applications would follow labeled use patterns or proposed use patterns.

Resistance Data. We plan to collect mites after applications of Acramite during the 2022 growing seasons from multiple fields. These mites will be assayed for the genes associated with Acramite resistance.

Anticipated Benefits and Information Transfer:

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

Budget:	**2021**	**2022**	**2023**
Salaries	5,000	3,500	4,000
Operations	1,000	990	1,000
Travel	500	650	650
Contract Research*	4,000	6,200	6,200
Benefits	1,500	1,155	1330
Total	**$12,000**	$**12,495**	**$13,180**

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

2022 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

New Project Proposal **Proposed Duration:** 4 years

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

PI: Alan Schreiber
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Co-PI: TBD
Organization: Washington State University
Title: Assistant Professor
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City/State/Zip: Mt Vernon, WA

Cooperators: Northwest Berry Foundation, Skagit County Pest Board

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

Total Project Request: **Year 1** $11,984 **Year 2** $11,984 **Year 3** $12,640

Other funding sources: A proposal has been submitted to the Washington State Commission on Pesticide Registration for $12,310. A Specialty Crop Block Grant to further support this project is expected to be submitted to WSDA with Washington State University as the lead in January. If this project is accepted, it would start in year 2023.

Description: The presence of spotted wing drosophila (SWD) has completely upended insect management in raspberries and has resulted in increased insecticide applications, the development of secondary pests including aphids, mites, leafroller and other lepidopteran pest outbreaks. As a result of this, growers have increased insecticide residues which in turn causes problems meeting maximum residue limit (MRL) issues which creates obstacles to export. This project proposes to change insecticide use practices, conserve beneficials, increase scouting intensity to prevent secondary pest outbreaks, and reduce insecticide residues at time of harvest.

Justification and Background:

Historically, Washington raspberry crops received three to five insecticide/miticide applications per season. In 2010, spotted wing drosophila (SWD) was first detected in Washington raspberry fields and the pest rapidly covered the state and became the overwhelming insect pest of raspberries. Currently growers with a competent conventional SWD program will make up to six applications in a typical season, and during years of heavy insect pressure, this number can reach eight applications particularly in later varieties. About 70% of Washington blueberries are grown for the IQF (individual quick frozen) market. There is zero tolerance for SWD maggots in raspberries in this market. A single detection in processed fruit can and has, resulted in rejection of an entire shipment. As a result of this standard, growers are under tremendous pressure to prevent every female fly from ovipositing in raspberries. Raspberries became susceptible to oviposition once they have reached 50% color (red) and remain susceptible until harvest is over for a period of time, perhaps six to eight weeks depending on location, variety and time of the year.

Raspberries are much more susceptible to SWD than any other berries such as blueberry and strawberry. There is much less room for error in raspberry SWD programs. Raspberries also have fewer insecticides to use against SWD than do other berries, for example, the industry does not have access to methomyl (Lannate) as do other berries.

Further complicating the situation is Washington's position as the leading exporter of processed raspberries, which is a lucrative high value market. However, to export raspberries, growers/exporters have to meet a host of foreign MRL requirements. Products with acceptable MRLs are mostly older products and largely consist of pyrethroid, organophosphate, carbamate, and neonicotinoid insecticides. Diazinon, a common and important insecticides with favorable MRLs is not going to be reregistered so eventually this product will be unavailable for berry growers. These products while highly effective against SWD tend to be broader in spectrum. This is particularly true for the pyrethroid insecticides. The use of these products largely removes beneficial organisms from raspberry fields. The lack of beneficial organisms such as parasitoids, predator insects, and mites result in the flaring of secondary pests including aphid species, two spotted spider mites, oblique banded leafrollers, and other lepidopterous pests. The outbreak of these secondary pests has necessitated applications of additional insecticides and miticides. This increases the cost of production and further complicates complying with MRLs.

The Washington raspberry industry recently completed an extensive research project that generated residue decline curves for the most important insecticides and fungicides used on the crop. Also, there have recently been some new products registered for raspberries, and the efficacy of some have been successfully screened against SWD. Some of these products hold significant promise for improving SWD management.

This project proposes to initiate a four-year insect IPM project. The project will combine intensive scouting of raspberry fields for pest and beneficial organisms, use of new selective insecticides such as SpearLep, SpearT, Coragen, and Verdipryn, as well as Radiant in lieu of broader spectrum products and use of residue decline curves to gain access to previously unusable products. Additionally, growers will be provided with increased access to entomological expertise to make insect pest management decisions.

Relationship between the raspberry IPM and blueberry IPM programs. While virtually all raspberry growers grow blueberries, more than half of blueberry growers do not grow raspberries. Both crops have SWD issues, secondary pest issues and MRL obstacles for their respective export markets. However, the industries have significant differences that require separate approaches. Pre-harvest intervals are quite different for the two crops. Blueberries are harvested two to five times, while raspberries are harvested every 36 hours or so and may be harvested more than 30 times. SWD pressure is heavier in raspberries than in blueberries. As a result of the above issues, secondary pests have been a bigger problem in raspberries, particularly for mites which are a comparatively much worse problem for raspberries than in blueberries. Raspberries have fewer products to manage insect pests than does the blueberry industry.

State how this project relates to other projects in British Columbia, Idaho and Oregon: When the Oregon industry learned about this project, they submitted a parallel proposal for Oregon. British Columbia is interested in cooperating with Washington on this project.

Relationship to WRRC Research Priority(s):
This project address WRRC #1 priorities related to SWD and mite, WRRC #2 priority related to cutworm/leafrollers and WRRC #3 priority related to MRLs.

Objectives:
Objective 1: Reduce secondary outbreaks of insect and mite pests of raspberries.
Objective 2: Reduce insecticide residues levels on raspberries at harvests that are obstacles to export.

Procedures: (400 words maximum)
An estimated 18 (9 pairs) raspberry fields and 2 (1 pair) blackberry fields will be intensely sampled for key pests and beneficial organisms on a weekly basis for sixteen weeks (2 in Skagit and 18 in Whatcom counties). The Skagit County Pest Board (Dr. Charles Coslor) will sample the blackberry fields in Skagit County. WSU Mt Vernon entomology program (Ben Diehl) will sample fields in Whatcom County. Schreiber's program will assist with the Whatcom County sampling. Information will be provided to the grower/crop advisor and the project principal investigator within 24 hours of sampling. Sampling will use pheromone traps, sticky cards, leaf samples and other sampling techniques.

Fields will be paired, so if 20 fields are included in the program there will be 10 pairs. The paired fields will be close to each other and have the same variety. One field of the pair will be managed using the growers' standard pest management system. The corresponding field will be managed in consultation with the project principal investigator. Beneficial organism counts will be incorporated into pest management decision making. Residue decline curves will be used when selecting insecticides as well as using products known to be safe to parasitoids and predators. Finally, products that are exempt from MRLs will be incorporated into management programs. For example, the newly registered Spear-T, which has a zero day preharvest interval, is exempt from tolerances (MRLs) and has activity against SWD, aphids, and mites (SWD efficacy data was generated using WSCPR support.) Most fields have already been identified and growers have agreed to participate in the program. There is much interest on the part of growers to change their pest management practices as the current trajectory of insecticide use is considered to be unstainable.

At the end of the season comparisons will be made between the pairs of fields and insecticides, for all yield and grade data as well as any information on insect contamination or damage that was detected for the field. The cost of insecticides applied will be calculated for each field.

Anticipated Benefits and Information Transfer:

We hope to reduce mite, aphid, and leafroller outbreaks in raspberries and reduce troublesome insecticide residues that create obstacles to exports. Information from this project will be communicated to growers by providing written reports for distribution by the Washington Red Raspberry Commission and in growers meetings such as the CHS grower meeting and the Washington Small Fruit Conference. Additionally, the PIs will work closely with crop advisors, exporters and others that make key pest management decisions to communicate results in near real time.

Budget:

	2022	2023	2024
Salaries[1/]	$7,500	$7,500	$8000
Time-Slip	$	$	$
Operations (goods & services)	$ 875	$ 875	$1,000
Travel[2/]	$ 892	$ 892	$1,000
Meetings	$	$	$
Other	$	$	$
Equipment[3/]	$	$	$
Benefits[4/]	$2,717	$2,717	$2,640
Total	**$11,984**	**$11,984**	**$12,640**

Budget Justification

[1/]This covers some of Alan Schreiber, Tom Walters time as well as time for WSU entomology technician Ben Diehl.

[2/]Travel is to and from field sites

[4/]this is for normal benefits for researchers.

2022 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

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

Project Title: European strawberry blossom weevil (*Anthonomus rubi*) survey

PI: Chris Looney
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Co-PI: Chris Benedict
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Title: Extension Professor
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Address: 1000 N Forest St
Address 2: Suite 201
City/State/Zip: Bellingham/WA/98225

Cooperators:

Year Initiated_____ Current Year 2022 Terminating Year 2022

Total Project Request: **Year 1** $17,859 **Year 2 $** **Year 3 $**

Other funding sources: Plant Protection Act funding has been requested to conduct a survey for five insect pests and two pathogens affecting small fruit, none of which are known from Washington (aside from *A. rubi*). That project, if awarded, will only support presence-absence data for the seven targets across the entire state. This proposal requests support for more detailed research on host impacts, phenology, and natural enemy surveys in Whatcom and Skagit counties, with the specific goal of helping develop management recommendations.
Agency Name: USDA-APHIS
Amt. Requested/Awarded: $78,712
Notes: The PPA funding is required to be spent on state-wide survey for seven plant pests/pathogens. If both are awarded, we will use the commission and PPA money to support a field technician based entirely in Whatcom and Skagit county. Fifty percent of that technician's time will be spent exclusively on the objectives described in this proposal, with the remainder of the position supported through PPA and other projects. If the PPA funding is received, the costs of vehicle and cell-phone (i.e. data collection device) described in the budget will also be shared across projects.

Description: This proposal is to survey cultivated and wild hosts of the strawberry blossom weevil, *Anthonomus rubi*, a newly detected pest in Washington State, to better understand the biology and incidence in cropping systems for designing management recommendations. *A. rubi* is among the most economically significant pests of cultivated *Rubus* and *Fragaria* in Europe, where it is endemic. The beetle was discovered in British Columbia in 2019, and subsequent surveys have documented that it is broadly established in the Fraser lowlands and Whatcom County. This project will survey for the beetle in cultivated fields and wild hosts in Whatcom and Skagit counties. The survey will employ a rigorous approach to estimate damage rates and quantify site- and host-specific abundance. We will collect detailed phenological data across the growing season and attempt to rear parasitoids from multiple sites, since one suspect natural enemy (Hymenoptera: Pteromalidae) is apparently associated with this beetle in the Pacific Northwest (Franklin et al. 2021, WSDA unpublished data). The data collected will be shared broadly, and used by WSU Extension and growers to develop scouting and control strategies.

Justification and Background:

Figure 1. Female *Anthonomus rubi* collected in Whatcom County, WA, 2021.

Anthonomus rubi (Fig 1) is a univoltine weevil that is an economic pest of *Rubus*, *Fragaria*, and *Rosa*. The species oviposits into young buds in the spring, after which the female girdles the bud stalk to retard growth and subvert plant defenses. The larvae feed on pollen within the damaged or fallen bud, with adults emerging throughout the summer to feed and mate prior to overwintering in the soil. Although univoltine, its activity period seems to span the entire growing season in the Pacific Northwest (Franklin et al. 2021, Roueché et al. *in review*), and mean fecundity for females has been estimated at over 150 eggs (Aasen et al. 2004). In its native range it is frequently rated as one of the four most significant pests of raspberries. Damage is site- and cultivar-specific, with flower loss in controlled experiments ranging from about 1 to 23% (Arus et al. 2008.); under field conditions, attack rates in raspberry range from insubstantial to over 50% (Stamenković et al. 2010). Weevil populations seem to be very responsive to weather conditions, with populations notably higher when spring and early summers are warm and dry (Veszelka and Fajcsi 2003, Arus et al. 2008).

The weevil was only detected in North America in 2019 (Franklin et al. 2021), but already appears to be well established in BC and Whatcom County (Franklin et al. 2021, Roueché et al. *in review*; Fig. 2). There is ample host plant material comprising multiple species and genera throughout the region which, coupled with the species' capacity for flight, guarantee the continued spread of the insect. It is not clear whether the beetle will have economic impacts, or if control approaches for existing pests will be sufficient to manage this species. Based on its potential impacts, USDA-APHIS has amended host plant import regulations from Canada, and the California Dept. of Food and Agriculture has proposed an "A" pest rating for the weevil. Being prepared to help growers manage the insect will be critical to regional agriculture, and an AAFC-led effort to integrate multiple aspects of control and information sharing is already underway in Canada (M. Franklin, pers. comm.). WSDA and WSU Extension propose to contribute to this effort by collecting similar data in NW Washington State, which will be used to develop monitoring and control strategies for this pest in cultivated crops.

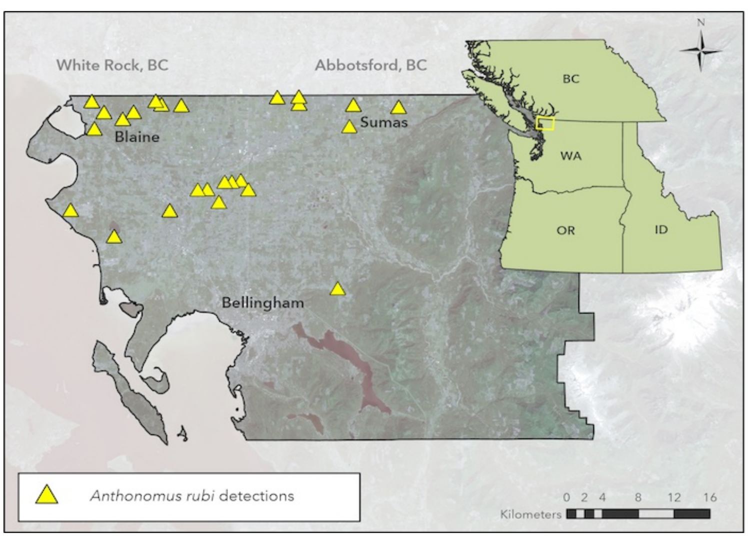

Figure 2. *Anthonomus rubi* in Washington State, 2021 (Roueché et al. *in review*)

Relationship to WRRC Research Priority(s): The strawberry blossom weevil is not addressed in the commission's research priorities, although it was only recently confirmed in the area. This proposal contributes generally to the understanding and management of raspberry pests. By acting quickly to collect basic biological data about this species in our region we can best position growers and researchers to develop control strategies if warranted.

Objectives:

1. **Document SBW phenology** in Whatcom and Skagit counties.
2. **Quantify impacts of the weevil** on cultivated and wild *Rubus* and its use of other host plants (e.g. *Rosa*).
3. **Document geographic distribution and spatially explicit abundance** in Whatcom and Skagit counties.
4. Collect potential **natural enemies** for further research.

Procedures:

Samples will be collected from sites across the two counties between April and September, over a two-week period during each month. The data collection protocol is still being developed in collaboration with entomologists in British Columbia, but will incorporate a per-stalk sample regime, evaluation of bud damage, and bud dissection to quantify each life stage. Site selection will be based on a semi-regular grid established across each county, up to the foothills of the Cascade Range. Sites selected will include feral host sites (e.g. blackberry thickets and wild roses), community gardens, and production fields. Data will be collected using a Survey123 tool and a GIS-enabled smartphone or tablet. Sites will be re-visited throughout the season to capture site-specific variability through time. At each collection date, additional samples (i.e. not those used for evaluating infestation level) will be taken from every site for rearing, to track adult emergence and the emergence of the suspect natural enemy. The data will be used to model population dynamics and landscape ecology, and evaluate host and cultivar susceptibility.

Anticipated Benefits and Information Transfer:

The weevil can be a significant pest of raspberries when uncontrolled (Milenkovic and Stanisavljevic 2003), although its impacts vary widely with local conditions (Veszelka and Fajcsi 2003) and are unclear in the PNW. We will collect basic information and complement the efforts in British Columbia, contributing to decision support tools for growers across the region. US participation in this effort will ensure local conditions and data are included in this multi-agency project, and facilitate communicating the results of this nascent research directly to US-based growers. This will occur through outreach publications produced with collaborators, presentations at industry events, and peer-reviewed research.

References:

Arus L, Luik A, Libek A, Olep K (2008) The damage of the strawberry blossom weevil (*Anthonomus rubi*) depending on raspberry cultivars and mulching in Estonia. *in* Sustainable fruit growing: From plant to product. May 28-31, 2008 Jūrmala - Dobele, Latvia pp. 244-249.

Aasen S, Hàgvar EB, Trandem N (2004) Oviposition pattern of the strawberry blossom weevil *Anthonomus rubi* Herbst (Coleoptera: Curculionidae) in Eastern Norway. Norwegian Journal of Entomology 51: 175-182.

Franklin, M.T., T. K. Hueppelsheuser, P. K. Abram, P. Bouchard, R. S. Anderson, and G. A. P. Gibson. 2021. The Eurasian strawberry blossom weevil, *Anthonomus rubi* (Herbst, 1795), is established in North America. The Canadian Entomologist 153: 579-585.

Milenkovic S, Stanisavljevic M (2003) Raspberry pests in Serbia. IOBC/wprs Bulletin 26: 23-27.

Roueché ND, Wilson TM, Looney C, Chamorro ML (in review) *Anthonomus rubi* (Herbst) (Coleoptera: Curculionidae) in Washington State and the United States of America. *Submitted to* the Proceedings

of the Entomological Society of Washington.
Stamenković S, Gudžić S, Deletić N, Sladić S (2010) Pest entomofauna of raspberry in the production area of Ivanjica. *in* 45th Croatian & 5th International Symposium on Agriculture, pp. 1134-1137.
Veszelka MS, Fajcsi M (2003) Changes of the dominance of arthropod pest species in Hungarian raspberry plantations. IOBC/wprs Bulletin 26: 29-36.

Budget:

	2022	2023	2024
Salaries[1/]	$ 8,556	$	$
Time-Slip	$	$	$
Operations (goods & services)	$ 650	$	$
Travel[2/]	$ 2,700	$	$
Meetings	$	$	$
Other	$ 854	$	$
Equipment[3/]	$	$	$
Benefits[4/]	$ 5,099	$	$
Total	**$ 17,859**	**$**	**$**

Budget Justification
Funding is requested to support one agricultural aid at 50% for six months, plus benefits. This will allow survey and rearing activities from at least April through September, which we believe encompasses the weevil's activity period. (Agricultural Aide: $1426/mo (0.5FTE) for 6 mo; benefit rate = 59.6% salaries)

Travel costs are requested for 6 months of vehicle use, and local mileage to multiple sites across Whatcom and Skagit counties. (WA state vehicle rental, $330/mo; Mileage ~800/mo @ $0.15 per mile) Funding for supplies to facilitate field collections and subsequent rearing, and funds for field-data collection software licenses and email are also requested. (email, $37.32/mo; Cell phone and field mapping software $103/mo).

Current & Pending Support: Chris Looney

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

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
ACTIVE					
Looney C	USDA Plant Protection Act AP20PPQFO000 C480	$120,000	7/01/2021-06/30/2022	5%	Exotic pest identification center
Looney C Spears RL Gilligan TM	USDA Plant Protection Act AP21PPQS&T00 C152	$22,422	6/1/2021-5/31/2022	10%	Assessing bee bycatch in exotic pest trap technologies
Looney C	WA State General Fund	$189,000	7/01/2021-6/30/2022	25%	WSDA Entomology program support
Looney C	USDA Plant Protection Act AP21PPQS&T00 C010	$65,285	9/1/2021-8/31/2022	5%	Giant hornet molecular research

Looney C Gillespie S Klinger E Koch J Ponisio L Waters S	NIFA, AFRI 2022-67013-36286	$678,880	4/1/2022- 3/31/2026	25%	A holistic approach to determining the impact of an established exotic pollinator, *Bombus impatiens*, on bumble bee health in the Pacific Northwest.
PENDING					
Looney C	USDA Plant Protection Act	$39,786	4/1/2022-3/31/2023	10%	Comprehensive survey of wild and managed bees captured in sticky traps
Looney C	USDA Plant Protection Act	$78,712	7/1/2022-6/30/2023	5%	Small fruit commodity survey
Looney C	Red Raspberry Commission (this proposal)	$17,859	3/1/2022-2/28/2023	10%	European strawberry blossom weevil (*Anthonomus rubi*) survey

Current & Pending Support: Chris Benedict

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

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
ACTIVE					
Benedict, C., D. I. Burke, D. LaHue, T. Potter, G. LaHue, N. Singh	WSU CSANR	$40,000	1/1/2021-12/31/2022	10%	Tracking the Tango Between Weeds, Soil Health, and Tillage.
DeVetter, L., H. Zhang, C. Miles, C. Benedict	WRRC	$39,785	1/1/2019- 12/30/21	1%	Multi-season plastic mulches for improved weed management and crop growth
C. Benedict, I. Burke, S. Galinato, G. Hoheisel, S. Seefeldt	WA Blueberry Commission	$15,199	3/1/21 - 2/29/22	15%	Spot Spraying of Blueberry Herbicides
C. Lavoto Niles, C. Benedict	Whatcom County Public Utility District	$9,787	9/1/21 - 10/1/22	1%	Whatcom County Extension Gardening Green Short Course
C. Benedict, B. Guindersen, T. Waters, D., McMoran	Northwest Potato Consortium	$24,000	7/1/19 - 6/30/21	5%	Controlling latent infections of black dot with early fungicide applications

G. LaHue, D. Griffin, L. DeVetter, C. Benedict	WA Blueberry Commission	$17,053	1/1/19 - 12/31/21	1%	Soil organic matter nitrogen mineralization
S. Seefeldt, C. Benedict	WBC	$10,325	01/01/2020-12/31/2022	1%	Chlorsulfuron Efficacy
S. Seefeldt, C. Benedict	W RRC	$11,452	01/01/2020-12/31/2022	1%	Preventing Wild Buckwheat Seed Production in Raspberries
PENDING					
Looney C, Benedict C	Red Raspberry Commission (this proposal)	$17,859	3/1/2022-2/28/2023	1%	European strawberry blossom weevil (*Anthonomus rubi*) survey

PHYSIOLOGY

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2022 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

Project Title: Determining optimal timing of mulch removal in floricane raspberry

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

Cooperators: None

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

Total Project Request: $23,679 **Year 1** $8,660 **Year 2** $15,019

Other funding sources: None at this time, but collaborators and I have received WSDA funding in 2018 to evaluate non-degradable polyethylene and biodegradable plastic mulch application in spring- and late-summer-planted raspberry. Another WSDA proposal will be submitted with Dave Bryla focused on optimizing irrigation and fertilizer management under plasticulture in floricane raspberry. This proposal is a separate project, but overall related to program efforts targeted at fine-tuning mulch use in northwest Washington raspberry.

Description:
Plastic mulches made from both non-degradable [e.g., polyethylene (PE)] and biodegradable feedstocks have shown to be effective at improving establishment of tissue-culture raspberry transplants through optimization of soil temperature and improved weed management (Zhang et al., 2019, 2020, 2021). PE mulch has been the most widely adopted plastic mulch among raspberry growers and requires removal and disposal at some point in the raspberry production cycle. The optimal time for mulch removal is unknown and important to address so growers can maximize on the benefits provided by mulches without limiting primocane growth. This proposal will address this knowledge gap by identifying optimal times to remove mulch in both spring- and late-summer planted floricane raspberry.

Justification and Background:
Plastic mulches have been a promising tool to aid in tissue culture plant establishment for Washington raspberry growers. Earlier experiments led by the DeVetter lab showed spring-planted 'WakeField' grown with either PE or soil-biodegradable mulch (BDM) can achieve a 31-41% yield gain in their first harvest year compared to plants grown without mulch (Zhang et al., 2019). This yield increase covered the expense of the mulch and increased first-year net returns relative to the standard grower practice of establishing plants without mulch. Increases in yield is attributed to warmer soil temperatures under black plastic mulch and improved weed management, which stimulates primocane growth during planting year. However, yield gains were not observed in a 'WakeHaven' late-summer planted trial (Zhang et al., 2020). Growers utilizing both planting systems are nevertheless experimenting with or adopting plastic mulch on their own farms, likely due to improved crop growth, the potential for yield gains, and improved weed management.

Despite the yield gains observed in the first harvest year of the spring-planted trial (Zhang et al., 2019), these increases in yield were not sustained in the subsequent year. One reason is that mulches may limit primocane growth that will support next season's crop. To address this, we propose the following study where different mulch removal times and their effects on subsequent crop performance is evaluated. Furthermore, removed mulch contains soil debris that acts as a recycling contaminant. In order to see if mulch removal time limits this contamination, we propose to also use this proposal as an opportunity to see if different removal times impact contamination load.

Relationship to WRRC Research Priority(s):
This proposal addresses the top-tier priority, "labor saving practices", as mulch use can reduce hand weeding and herbicide application needs. It also addresses the third-tier priority, "alternative management systems", given mulch application is still a new practice among the floricane raspberry industry.

Objectives:

1. Determine the optimal timing for mulch removal in spring- and late-summer planted floricane raspberry (Years 1-2)
2. Disseminate findings (Years 1-2)

Procedures:
Objective 1. For spring-planted raspberry, we will work with a grower cooperator in Lynden, Washington, that planted raspberry using mulch in Spring 2022. Following this, a randomized complete block design will be established with 9 treatments representing different mulch removal times including: 1) July 2022; 2) Aug. 2022; 3) Sept. 2022; 4) Oct. 2022; 5; Nov. 2022; 6) Dec. 2022; 7) Jan. 2023; 8) Feb. 2023; and 9) March 2023. Individual treatment plots will be ~60 ft long spanning two post lengths. The time for a 2-person crew to remove mulch will be measured at each removal time. Samples of the removed mulch will be analyzed in DeVetter's lab to determine how much soil adheres to the mulch at each removal time. This measurement will be used to estimate topsoil removal for each sampling time and to characterize contamination load, as soil is the key contaminant that limits mulch recycling. Yield will be measured in 2023 at three timepoints (early, mid, and late) to assess treatment effects on yield. In

Sept. 2023, primocane height and number will be measured from 10 plants per plot to determine which removal time minimizes the potential for primocane reduction.

The late-summer planted trial will be executed the same as the spring-planted trial. However, we will work with a grower cooperator in Lynden that planted raspberry late-summer 2021 and remove mulch at the following timepoints. 1) July 2022; 2) Aug. 2022; 3) Sept. 2022; 4) Oct. 2022; 5; Nov. 2022; 6) Dec. 2022; 7) Jan. 2023; 8) Feb. 2023; and 9) March 2023.

Objective 2. Results will be shared annually at regional conferences. Information from the project will be made available on the Plastic Mulch portion on DeVetter's website (https://smallfruits.wsu.edu/plastic-mulches/).

Anticipated Benefits and Information Transfer:
Results from this project will provide information on optimal mulch removal times in both spring- and late-summer planted raspberry systems. This will help ensure the benefits of mulching are achieved without limiting primocane growth needed to sustain next years' crop. Information will be transferred annually at regional conferences. In addition, results will be made available on the Plastic Mulch portion on DeVetter's website (https://smallfruits.wsu.edu/plastic-mulches/) and also circulated in 2023 in a *Whatcom AgMonthly* newsletter. Mulch contamination data will be shared with regional recyclers to assess recycling feasibility of used plastic mulch. Results will also be published in the peer-reviewed literature.

References:
Zhang, H., C. Miles, B. Gerdeman, D.G. LaHue, and L.W. DeVetter. 2021. Plastic mulch use in perennial fruit cropping systems - A review. Scientia Horticulturae. https://doi.org/10.1016/j.scienta.2021.109975.

Zhang, H., C. Miles, S. Ghimire, C. Benedict, I. Zasada, H. Liu, and L.W. DeVetter. 2020. Plastic mulches improved plant growth and suppressed weeds in late summer-planted floricane raspberry. HortScience 55:565–572.

Zhang, H., C. Miles, S. Ghimire, C. Benedict, I. Zasada, and L.W. DeVetter. 2019. Polyethylene and biodegradable plastic mulches improve growth, yield, and weed management in floricane red raspberry. Scientia Horticulturae 250:371-379.

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

	2022	2023
Salaries[1/]	$2,118	$4,406
Time-Slip[2/]	$3,600	$4,493
Operations (goods & services)[3/]	$200	$200
Travel[4/]	$261	$522
Meetings	$	$

Other	$	$
Equipment	$	$
Benefits[5/]	$2,481	$5,398
Total	$8,660	$15,019

Budget Justification

[1/] Technician support at 0.5 month at 100% FTE in Year 1 and 1 month in Year 2.

[2/] Timeslip support for field and lab data collection at $18/hr x 20 hrs/wk x 10 weeks in Year 1 and $18/hr x 40 hrs/wk x 6 weeks in Year 2.

[3/]Sample bags, scale recalibration and batteries, sponges for mulch cleaning.

[4/] Roundtrip in-state travel to field sites for project data collection at 90 miles round trip @ $0.58/mile for 5 trips in Year 1 and 10 trips in year 2.

[5/]Benefits for technician at 40.3% and timeslip at 9.8% (Year 1) and 80.7% (Year 2). Note, due to new labor laws in Washington State, our timeslip benefit rates are increasing and higher than previous proposals. *Approved by Lisa Friend on 11/19/2021

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
DeVetter, L., C. Miles, D. Griffin, M, Flury, M. Bolda, S. Wortman, S. Agehara, C. Benedict, H. Liu, T. Marsh, T. Chi, S. Galinato, K. Englund, M. Perez-Garcia, G. Yorgey, J. Goldberger, and L. McGowen	USDA SCRI	$49,234	9/2019-8/2022	5%	Planning grant: Implementation of new technologies and improved end-of-life management for sustainable use of agricultural plastics
Iorizzo, M., P. Munoz, J. Zalapa, N. Bassil, D. Main, D. Chagne, L. Giongo, K. Gallardo, E. Canales, A. Atucha, L.W. DeVetter	USDA 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
DeVetter, L.W., T. Peever, S. Galinato, and S. Jung	Washington State Department of Agriculture Specialty Crop Block Grant (WSDA SCBG)	$249,963	10/2019-9/2022	4%	Novel production systems for improved production and disease management in strawberry
DeVetter, L.W.., C. Miles, C. Benedict, I.A. Zasada, H. Zhang, S. Ghimire	WSDA SCBG	$249,959	10/2018-9/2022	2%	Promoting productivity and efficiencies in red raspberry systems through application of biodegradable plastic mulches
DeVetter, L.W., F. Takeda, J. Chen, S.	WSDA SCBG	$178,328	10/2018-10/2022	2%	Improving machine harvest efficiency and fruit quality for

Korthuis, and W. Yang					fresh market blueberry
Lukas, S., L.W. DeVetter, B. Strik, D. Bryla, J. Fernandez-Salvador, and S. Galinato	USDA ORG	$500,000	8/19-7/23	3%	Management techniques to optimize soil pH and nutrient availability in organic highbush blueberry grown east of the Cascade Rang
G. Hoheisel, L. DeVetter, L. Khot, and C. Kogan	WBC	$27,100	1/2020-12/2021	2%	Modeling blueberry cold hardiness in Washington
Miles, C., C. Benedict, M. Flury, H. Liu, L.W. DeVetter, and S. Galinato	WSARE PDP	$74,580	10/19-9/22	4%	In-service training for biodegradable mulch
Sankaran, S., A. Carter, K, Evans, K. Garland-Campbell, S. Ficklin, S. Gupta, A. Kalyanaraman, R. McGee, S. Serra,	National Science Foundation Research Experience for Undergraduates (NSF REU)	$389,170	1/2020-12//2022	2%	REU site: Phenomics Data integration and analytics in crop improvement
Isaacs, R., R. Mallinger, L. DeVetter, S. Galinato, P. Edgar, and A. Melathopoulos	USDA SCRI	$4 mil	10/2020-9/2024	10%	Optimizing blueberry pollination to ensure future yields
DeVetter, L.W., J. Davenport, G. Hoheisel, and G. LaHue	Northwest Center for Small Fruits Research (NCSFR)	$141,258	9/2020-9/2023	4%	Optimizing nutrient management for organically grown blueberries east of the Cascade Range
DeVetter, L.W., C. Miles, and S. Watkinson	WRRC	$15,002	1/2021-12/2021	2%	Evaluation of multi-season plastic mulches in mature raspberry production
DeVetter, L.W, C. Mattupalli, D. Brown, D. Harteveld, M. Cucak, and D. Brown	WBC	$12,133	1/2021-12/2022	1%	Optimizing the management of mummy berry using an online decision support tool
DeVetter, L.W., G. LaHue, M. Borghi, S. Watkinson, A. De La Luz	WBC	$22,081	1/2021-12/2022	3%	Pollinator attraction - Nectar, pollen, and assessment of new technologies
Gramig, G., L.W. DeVetter, S. Galinato, D. Bajwa, and S. Weyer	USDA OREI	$3 mil	10/2021-9/2025	5%	MulcH2O: Biodegradable composite hydromulches for sustainable organic horticulture

PENDING:

DeVetter, L.W., K. Englund, T. Marsh, J. Goldberger, S. Agehara, and S. Sistla	USDA SCRI	$8 mil	10/2022-9/2026	10%	Improving end-of-life management of plastic mulch in strawberry systems
DeVetter, L.W., D. Bryla, D., M. Hardigan, M. Zamora Re, K. Gallardo, S. Galinato, and W. Hoashi-Erhardt	USDA OREI	$3 mil	10/2021-9/2025	7%	Beat the heat - Mitigating heat damage in caneberry
Bryla, D., W. Yang, and L.W. DeVetter	Washington Blueberry Commission/Oregon Blueberry Commission	$15,820	07/2022-6/2023	1%	Fertigation practices for increasing calcium content and improving fruit quality and shelf life of conventional and organic blueberries
Jung, S., A. Khan, K.C. Park, and L.W. DeVetter	National Science Foundation	$1,000,000	3/2022-2/2024	3%	Predictive intelligence for atmospheric incursions of plant pandemics
Hoashi-Erhardt, W., and L.W. DeVetter	WRRC	$80,614	1/2022-12/2022	3%	Red raspberry breeding, genetics and clone evaluation
DeVetter, L.W., C. Luby, C. Mattupali, J. DeLong, V. Stockwell, and S. Lukas	WBC	$13,480	1/2022-ongoing	5%	Evaluating new blueberry cultivars and advanced selections in the Pacific Northwest
DeVetter, L.W., M. Borghi, G. LaHue, A. De La Luz, and T. Sade	WBC	$33,768	1/2021-2/2022	3%	Pollinator attraction - Nectar, pollen, and assessment of new technologies
DeVetter, L.W.	WRRC	$23,679	1/2021-12/2023	2%	Determining optimal timing of mulch removal in floricane raspberry
DeVetter, L.W. and D. Bryla	WRRC	$60,386	1/2021-12/2023	3%	Calcium accumulation and increasing fruit uptake in floricane raspberry

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2022 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

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

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Cooperators: None

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

Total Project Request: $60,386 **Year 1** $11,042 **Year 2** $24,289 **Year 3** $25,055

Other funding sources: None at this time, but we plan to submit a grant to the Northwest Center for Small Fruits Research to support this project.

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

Procedures:
Objective 1. In the first year of the study, we will measure Ca concentrations in established (3 year or older) ‘Meeker’, ‘WakeField’, and ‘WakeHaven’ raspberry fruits at a single site per cultivar in Whatcom County, Washington. Fruits will be sampled weekly from June 15 to Aug. 15, 2022 and all available fruit stages will be collected at each sampling timepoint (i.e., Stage 4—immature green fruit, Stage 5—mature green fruit, Stage 6—white fruit, Stage 7—white/red fruit, and Stage 8—red ripe fruit). Sample size will vary between 30-130 fruits per replicate due to fruit size differences across development. This sampling strategy will enable timing of Ca accumulation across different developmental stages to be assessed. In addition, leaf macro- and micronutrient concentrations will be measured on Aug. 1 to assess plant nutritional status and relate it to fruit nutrient data. In ‘Meeker’, we will also measure fruit stomatal conductance using a porometer from 10 berries per developmental stage, as well as from leaves when the majority of fruits are at Stage 5 (mature green). Stomatal conductance is a measure of stomata opening and is important for nutrient delivery into fruit.

Objective 2. To evaluate methods to increase Ca concentrations in raspberry leaves and fruits, a two-year on-farm trial will be established in 2023 with a grower-cooperator in Lynden, Washington. We will use a single cultivar ('WakeField' or 'Meeker') and establish the experiment as a randomized complete block design with four treatments applied to 60-ft long plots replicated five times. Our treatments will include: 1) foliar applications of calcium chloride; 2) soil applications of lime or gypsum (selection will depend on soil conditions at the experimental site); 3) fertigation with hydrolyzed gypsum; and 4) an untreated control. Treatment applications will follow the label and will be applied in 2023 and 2024. In both years, soil-solution Ca, as well as baseline and postharvest soil pH, EC, and macro- and micronutrients will be measured. Foliar and fruit nutrient analyses will also be completed yearly during standard tissue sampling times (Aug. 1). 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	$4,406	$4,582
Time-Slip[2/]	$3,456	$11,232	$11,681
Operations (goods & services)[3/]	$1,730	$1,145	$2,645
Travel[4/]	$522	$522	$522
Meetings			
Other[5/]	$800	$2,960	$1,440
Equipment			
Benefits[6/]	$ 2,416	$4,024	$1,440
Total	$11,042	$24,289	$25,055

Budget Justification

[1/] Technical support for technician in Small Fruit Horticulture program at 0.5 month at 100% FTE in Year 1 and 1 month 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 and $18/hr x 40 hrs/week x 15 weeks in Years 2 and 3).

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

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

[5/]Subcontract for Bryla for travel and field trial for measuring Ca.

[6/]Benefits for technician at 40.3%. Timeslip benefits at 9.8% until July 1, 2022, after which rates increase to 80.7%. Note, due to new labor laws in Washington State, our timeslip and benefit rates are increasing and higher than previous proposals.

*Approved by Lisa Friend on 11/19/2021

Current and Pending for Dr. Dave Bryla

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
CURRENT					
Bryla, D.	Oregon Blueberry Commission	$31,500	07/01/19 – 06/30/22	5%	Comprehensive Management Strategies for Use of Biostimulants in Blueberry
Lukas, S., DeVetter, L., Bryla, D., Strik, B., Fernandez-Salvador, J., Galinato, S.	USDA NIFA Organic Transitions Grant #2018-03571	$485,857	08/01/19 – 07/31/22	7%	Management Techniques to Optimize Soil pH and Nutrient Availability in Organic Highbush Blueberry Grown East of the Cascade Range
Bryla, D.	Oregon Blueberry Commission	$21,900	07/01/20 – 06/30/22	5%	Improved Practices for Assessing Plant Water Needs and Scheduling Irrigation in Blueberry
Hummer, K., Bryla, D., Mackey, T., Orr, S., Anderson, T., Finn, C.	Oregon Blueberry Commission	$39,503	07/01/20 – 06/30/22	2%	Developing Commercial Blueberry Cultivars Adapted to the Pacific Northwest with Emphasis on Understanding Heritability of Cold and Heat Tolerance
Bryla, D.	Brandt	$7,565	01/01/21 – 12/31/22	3%	Evaluation of GlucoPro on Blueberries in the Pacific Northwest
Bryla, D.	Netafim International	$50,000	01/01/21 – 12/31/22	3%	A Research Trial on Practices for Improving Drip Irrigation of Blueberry in Substrate
Bryla, D., DeVetter, L., Yang, W.	Oregon Blueberry Commission/Washington Blueberry Commission	$15,300	07/01/21 – 06/30/22	5%	Fertigation Practices for Increasing Calcium Content and Improving Fruit Quality and Shelf Life of Conventional and Organic Blueberries
Bryla, D., Fernandez-Salvador, J.	Oregon Blueberry Commission	$11,200	07/01/21 – 06/30/21	5%	Irrigation and Cost and Benefits of Substrate Production of Blueberries in Oregon
Bryla, D., Peters, T.	Washington Blueberry Commission	$8,200	07/01/21 – 06/30/21	5%	A New Online Tool for Actuating Micro-sprinkler Cooling Systems to Prevent Heat Damage in Commercial Blueberry Fields
Bryla, D.	NCSFR	$119,422	10/01/21 – 09/30/24	8%	Improved Practices for Assessing Plant Water Needs and Scheduling Irrigation in Blueberry

PENDING:					
Bryla, D.	Oregon Blueberry Commission	$10,600	07/01/22 – 06/30/23	5%	Comprehensive Management Strategies for Use of Biostimulants in Blueberry
Bryla, D.	Oregon Blueberry Commission	$10,460	07/01/22 – 06/30/23	5%	Improved Practices for Assessing Plant Water Needs and Scheduling Irrigation in Blueberry
Bryla, D., DeVetter, L., Yang, W.	Oregon Blueberry Commission/Washington Blueberry Commission	$15,820	07/01/22 – 06/30/23	5%	Fertigation Practices for Increasing Calcium Content and Improving Fruit Quality and Shelf Life of Conventional and Organic Blueberries
Bryla, D.	Oregon Blueberry Commission	$11,500	07/01/22 – 06/30/23	5%	Irrigation and Cost and Benefits of Substrate Production of Blueberries in Oregon
Bryla, D.	Washington Blueberry Commission	$8,000	07/01/22 – 06/30/23	5%	A New Online Tool for Actuating Micro-sprinkler Cooling Systems to Prevent Heat Damage in Commercial Blueberry Fields
Zamora Re, M., Bryla, D., Lukas, S., Peters, T., Cahn, M.	USDA Specialty Crop Multi-State Program	$1,000,000	10/01/22 – 09/30/25	3%	Decision Support Tools for Optimizing Irrigation and Nitrogen Management of Blueberry
DeVetter, L., Bryla, D., Hardigan, M., Zamora Re, M., Gallardo, K., Galinato, S., Hoashi-Erhardt, W.	USDA Specialty Crop Multi-State Program	$1,000,000	10/01/22 – 09/30/25	6%	Beat the Heat - Mitigating Heat Damage in Caneberry

PATHOLOGY
VIROLOGY

Report to the Washington Red Raspberry Commission

Management of Fungicide Resistant Botrytis in Red Raspberry

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Objective

To evaluate the effect of different fungicides on raspberry botrytis control.

Materials and Methods

The staff at the Agriculture Development Group, Inc. started two trials near Everson, WA in June 2021 to evaluate the effect of different fungicides (Efficacy trial) and fungicide programs (Program trial) for the control of raspberry gray mold disease caused by *Botrytis cinerea*. The experimental design for this trial was a RCB with 4 replications and plot sizes of 10 ft x 25 ft. Applications for this trial were made with an over the row sprayer (Photo 1) calibrated to apply treatment sprays at 75 gallons per acre to cover both sides of raspberry canes. No maintenance fungicides were sprayed during this study to prevent the possibility of interfering with the existing trial's objectives.

For efficacy trial, five applications were made on 6/2 (A), 6/12 (B), 6/23 (C), 7/3 (D), and 7/20 (E). For program trial, six applications were made on 6/2 (A), 6/12 (B), 6/23 (C), 7/8 (D), 7/20 (E) and 7/22 (F). The phytotoxicity of each treatment was evaluated at each application after the first application, and at 7 and 14 days after the final application.

Due to low in-field infection rate, we did not obtain direct botrytis ratings in the field. As a result, to better assess the treatment effect, 30 raspberries from each plot were harvested on 7/20. It is important to keep in mind that this season had very dry and had repeated record hot temperatures reaching 112 degrees Fahrenheit. These environmental conditions prevented in field disease expression.

The collected fruits were then transferred to food service containers and stored for transport in coolers with cold packs. The following day, samples were transferred to moistened paper towels on 1/2" hardware cloth and were incubated in opaque sealed plastic containers at 60-65 F (Photo 2). The number of gray mold disease infected berries was counted on 7/22, 7/24, and 7/26, representing infection incidence at 2, 4, and 6 days after incubation (DAI).

Table 1. Efficacy trial. Effect of different fungicide programs on raspberry botrytis incidence in storage.

Crop Name				Red raspberry	Red raspberry	Red raspberry
Rating Date				7/22/2021	7/24/2021	7/26/2021
Rating Type				Botrytis incidence	Botrytis incidence	Botrytis incidence
Rating Unit/Min/Max				%, 0, 100	%, 0, 100	%, 0, 100
Days After First/Last Applic.				50, 2	52, 4	54, 6
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	1*	2*	3*
1	Untreated Check				11a	28a	99ab
2	Switch	14	oz/a	ABCDE	9a	38a	100a
3	PhD	6.2	oz/a	ABCDE	2a	42a	100a
4	Luna Tranquility	18	fl oz/a	ABCDE	7a	46a	98ab
5	Captan	2	lb/a	ABCDE	4a	37a	97b
6	Elevate	1.5	lb/a	ABCDE	2a	26a	100a
7	Pristine	23	oz/a	ABCDE	8a	39a	100a
8	Rovral 4F	2	pt/a	ABCDE	12a	39a	98ab
9	Proline	5.7	fl oz/a	ABCDE	6a	25a	99ab
10	Fontelis	20	fl oz/a	ABCDE	3a	24a	99ab
11	Kenja	15.5	fl oz/a	ABCDE	5a	24a	97b
12	Kenja	13.5	fl oz/a	ABCDE	6a	28a	100a
13	Propulse	13.6	fl oz/a	ABCDE	0a	18a	98ab
14	Inspire	7	fl oz/a	ABCDE	3a	28a	100a
15	Pyraziflumid	3.2	fl oz/a	ABCDE	3a	33a	100a
16	Miravis	10.3	fl oz/a	ABCDE	4a	27a	97b
17	Cevya	5	fl oz/a	ABCDE	5a	30a	99ab
LSD P=.05					8.5	20.1	2.7
Standard Deviation					6.0	14.1	1.9
CV					115.82	45.22	1.95
Replicate F					1.586	0.117	1.532
Replicate Prob(F)					0.2049	0.9499	0.2182
Treatment F					1.253	1.135	1.884
Treatment Prob(F)					0.2658	0.3520	0.0465

Rating Unit/Min/Max
%, 0, 100 = percent

Table 2. Program trial. Effect of different fungicide programs on raspberry botrytis incidence in storage.

Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	Botrytis sp.	Botrytis sp.	Botrytis sp.
	Crop Name				Red raspberry	Red raspberry	Red raspberry
	Rating Date				7/22/2021	7/24/2021	7/26/2021
	Rating Type				Botrytis incidence	Botrytis incidence	Botrytis incidence
	Rating Unit/Min/Max				%, 0, 100	%, 0, 100	%, 0, 100
	Days After First/Last Applic.				50, 2	52, 2	54, 4
					1*	2*	3*
1	Untreated Check				3.3a	23a	100a
2	Captan	2	lb/a	A	1.7a	28a	99a
	Switch	14	oz/a	A			
	Captan	2	lb/a	B			
	Pristine	23	oz/a	B			
	Captan	2.5	lb/a	C			
	Meteor	32	fl oz/a	C			
	Captan	2	lb/a	D			
	Switch	14	oz/a	D			
	Captan	2	lb/a	E			
	PhD	6.2	oz/a	E			
	Captan	2	lb/a	F			
	Switch	14	oz/a	F			
	SB-56 (NIS)	6	fl oz/100 gal	ABCDEF			
3	Captan	2.5	lb/a	A	8.3a	40a	99a
	Meteor	32	fl oz/a	A			
	Captan	2.5	lb/a	B			
	Pristine	23	oz/a	B			
	Captan	2.5	lb/a	C			
	Switch	14	oz/a	C			
	Captan	2.5	lb/a	D			
	Switch	14	oz/a	D			
	Captan	2.5	lb/a	E			
	PhD	6.2	oz/a	E			
	Switch	14	oz/a	F			
	SB-56 (NIS)	6	fl oz/100 gal	ABCDEF			
4	Captan	2.5	lb/a	A	1.7a	38a	100a
	Captan	2	lb/a	B			
	PhD	6.2	oz/a	B			
	Captan	2.5	lb/a	C			
	Switch	14	oz/a	C			
	Captan	2.5	lb/a	E			
	Switch	14	oz/a	E			
	SB-56 (NIS)	6	fl oz/100 gal	ABCD			
5	Captan	2.5	lb/a	A	4.2a	19a	100a
	Switch	14	oz/a	A			
	Captan	2.5	lb/a	B			
	Captan	2.5	lb/a	C			
	Captan	2.5	lb/a	E			
	Switch	14	oz/a	E			
	SB-56 (NIS)	6	fl oz/100 gal	ABCD			
6	Captan	1.5	lb/a	A	9.2a	41a	99a
	Captan	1.5	lb/a	B			
	Captan	1.5	lb/a	C			
	Captan	1.5	lb/a	E			
	SB-56 (NIS)	6	fl oz/100 gal	ABCD			
7	Captan	1.25	lb/a	A	4.2a	18a	99a

Switch	14oz/a	A			
Captan	1.25lb/a	B			
Pristine	23oz/a	B			
Captan	2.5lb/a	C			
Kenja	15.5fl oz/a	C			
Captan	1.25lb/a	D			
Switch	14oz/a	D			
PhD	6.2oz/a	E			
Kenja	15.5fl oz/a	E			
PhD	6.2oz/a	F			
Switch	14oz/a	F			
SB-56 (NIS)	6fl oz/100 gal	ABCDEF			
8Captan	2lb/a	A	1.7a	18a	99a
Meteor	32fl oz/a	A			
Captan	2lb/a	B			
Fontelis	20fl oz/a	B			
Captan	2.5lb/a	C			
Switch	11.2oz/a	C			
Captan	2lb/a	D			
Switch	11.2oz/a	D			
Captan	2lb/a	E			
PhD	6.2oz/a	E			
Captan	2lb/a	F			
Switch	11.2oz/a	F			
SB-56 (NIS)	6fl oz/100 gal	ABCDEF			
9Kenja	15.5fl oz/a	ACD	2.5a	21a	98a
Captan	2lb/a	ABCDEF			
PhD	6.2oz/a	B			
Meteor	32fl oz/a	E			
Switch	14oz/a	F			
SB-56 (NIS)	6fl oz/100 gal	ABCDEF			
10Elevate	1.5lb/a	A	5.8a	28a	98a
Meteor	32fl oz/a	B			
Elevate	1.5lb/a	C			
Pristine	20oz/a	DF			
Elevate	1.5lb/a	E			
SB-56 (NIS)	6fl oz/100 gal	ABCDEF			
11Fontelis	20fl oz/a	ACE	5.0a	36a	99a
PhD	6.2oz/a	BD			
Switch	14oz/a	F			
SB-56 (NIS)	6fl oz/100 gal	ABCDEF			
12Switch	14oz/a	A	1.7a	23a	100a
Luna Tranquility	16fl oz/a	B			
PhD	16oz/a	C			
Meteor	2qt/a	D			
Swtich	14oz/a	E			
PhD	16oz/a	F			
SB-56 (NIS)	6fl oz/100 gal	ABCDEF			
LSD P=.05			7.13	19.0	3.3
Standard Deviation			4.95	13.2	2.3
CV			120.88	47.57	2.33
Replicate F			0.135	1.646	1.505
Replicate Prob(F)			0.9383	0.1976	0.2313
Treatment F			1.101	1.785	0.568
Treatment Prob(F)			0.3911	0.0975	0.8400

Results and Discussion

Efficacy trial

No phytotoxicity was noticed among treatments throughout the trial period.

Although not significantly different, treatments of Switch, PhD, Luna Tranquility, Captan, Elevate, Pristine, Proline, Fontelis, Kenja high rate, Kenja low rate, propulse, Inspire, Pyraziflumid, Miavis, and Cevya showed 2%, 9%, 4%, 7%, 9%, 5%, 8%, 6%, 5%, 11%, 8%, 8%, 7%, and 6% numerically less botrytis incidence compared to the untreated check, respectively, on July 22. Treatments of Elevate, Proline, Fontelis, Kenja high rate, Propulse, and Miravis had 2%, 3%, 4%, 4%, 10%, and 1% numerically less botrytis incidence compared to the untreated check, respectively, on July 24. All treatments showed at or above 97% botrytis incidence on July 26, and no treatments showed significantly less incidence compared to the untreated check.

The results indicated that no treatments can reduce the incidence at 6 DAI, however, some treatments like Elevate, Proline, Fontelis, Kenja high rate, Propulse, and Miravis can reduce the botrytis incidence at 2 and 4 DAI, indicating the efficacy against botrytis in raspberry.

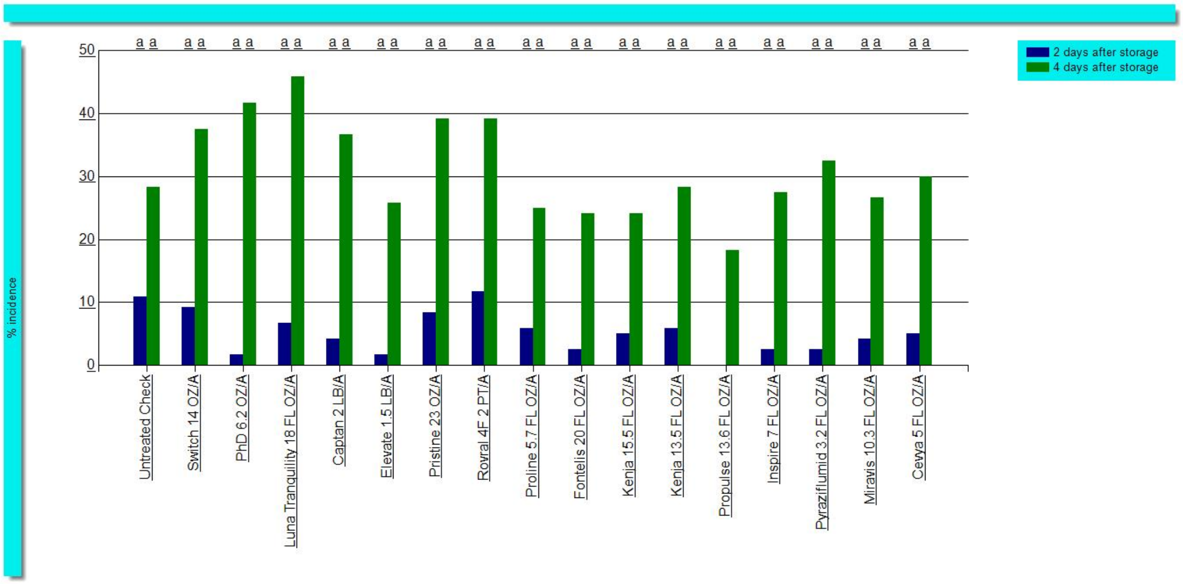
Program trial

No phytotoxicity was noticed among treatments throughout the trial period.

Although not significantly different, treatment 2, 4, 8, 9, and 12 showed 48%, 48%, 48%, 24%, and 48% numerically less botrytis incidence compared to the untreated check, respectively, on July 22. Treatment 5, 7, 8, and 9 had 17%, 22%, 22%, and 9% numerically less botrytis incidence compared to the untreated check, respectively, on July 24. All treatments showed at or above 98% botrytis incidence on July 26, and no treatments showed significantly less incidence compared to the untreated check.

The results indicated that no treatments can reduce the incidence at 6 DAI, however, treatments 8 and 9 can reduce the botrytis incidence at 2 and 4 DAI, indicating the efficacy against botrytis in raspberry.

Graph 1. Efficacy trial. Effect of different fungicides on raspberry botrytis incidence at 2 and 4 days after storage.



Graph 2. Program trial. Effect of different fungicide programs on raspberry botrytis incidence at 2 and 4 days after storage.

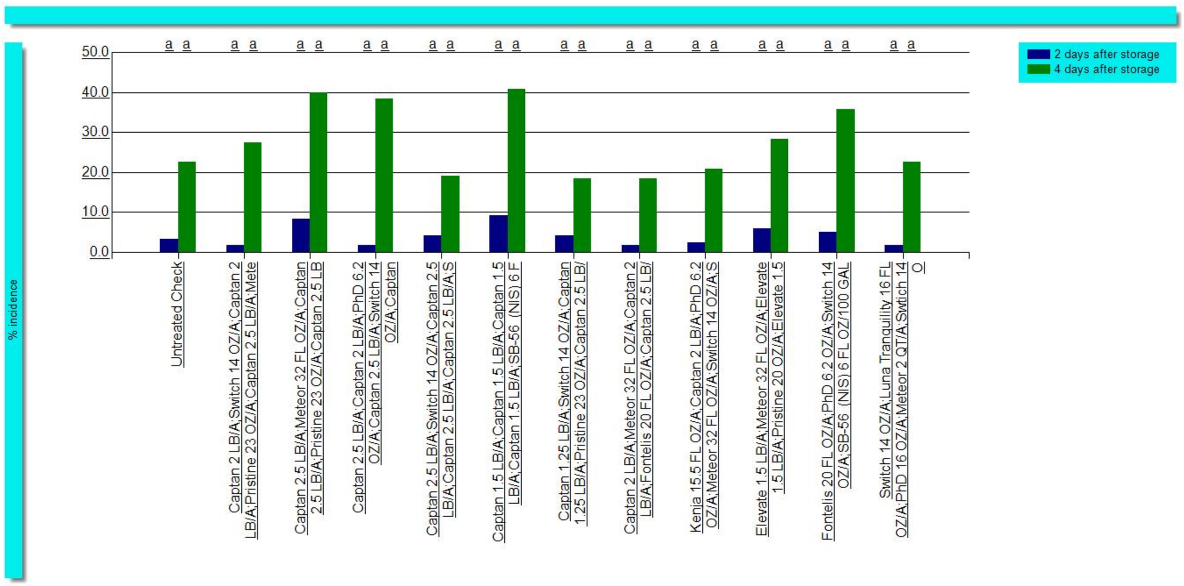


Photo 1. Application using over the row sprayer on raspberry.

Photo 2. Representative photos of raspberry in incubator.

Project Title: Cane blight control on raspberry-2021

PI: Alan Schreiber
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Cooperator: Lisa Jones, Northwest Plant Company.

Objective

To evaluate the effect of different fungicides on raspberry cane blight control.

Materials and Methods

A raspberry cane blight trial was conducted in June 2021 by Agricultural Development Group, Inc. about 6 miles south of Lynden, WA to evaluate the effect of different fungicides on raspberry cane blight. This is the third year of this project. The experimental design was a RCB with 4 replications with the plot size of 10 ft x 30 ft. Applications A and B for this trial were made via drip with the A timing being 1 month pre harvest and B timing being 1 days before harvest. The rest of the applications for this trial were made by an over the row sprayer to apply treatment spray at 35 gallons/acre during harvest. The AB applications for Velum Prime is the nematicide application timings for raspberry. There is an interest to know whether an applications for nematode will have any impact on cane blight. Application C started at 3 days before harvest. Both sides of each plot's raspberries were simultaneously sprayed to ensure complete coverage with the experimental products used. The rows of raspberries established for this trial were not treated with any maintenance fungicides to prevent the possibility of interfering with the existing trial's objectives.

The raspberry variety was WakeHaven, a variety with known susceptibility to the disease. The applications were made on June 11 (A), July 5 (B), July 3 (C), July 15 (D), July 27 (E), August 5 (F), August 18 (G). The raspberry plots were harvested from July 6 to August 18. The evaluation for the total number of floricanes that collapsed was on August 11. The total number of damaged primocanes and the number of infected primocanes were counted on October 31. Then the incidence for new primocane infections was calculated using infected canes divided by the total damaged canes.

Although this procedure was not on protocol, we thought Velum Prime applications for cane blight may have some impact on root-lesion nematode (RLN), so root samples (two 6 inch by 6 inch size) were collected before first application on June 11 and then at the end of the season on October 15. The total RLN per g root was evaluated by a USDA lab in Corvallis, Oregon (Dr. Inga Zasada). The RLN analysis was only for untreated check and Velum Prime treatments (4 replications per treatment) as the other products are known not to have nematicidal activity.

Table 1. Comparative efficacy of nine cane blight management programs on raspberry.

Rating Date					Jun-11-2021	Oct-15-2021	Aug-11-2021	Oct-31-2021
Rating Type					RLN/g root	RLN/g root	# infected floricanes	# infected primocane incidence
Number of Subsamples					1	1	1	1
Days After First/Last Applic.					0 0	126 58	61 6	142 74
Trt-Eval Interval					0 DA-A	126 DA-A	61 DA-A	142 DA-A
Number of Decimals					1	1	1	1
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	1	2	3	4
1	Untreated check				166.0a	717.3a	7.3a	37.7a
2	Velum Prime	237.5	g ai/ha	A	134.0a	17.0a	7.5a	36.4a
3	Velum Prime	237.5	g ai/ha	AB	559.6a	15.4a	9.5a	38.0a
4	Kenja	15.5	fl oz/a	CDEFGH			9.5a	23.2a
5	Luna Tranquility	16.42	fl oz/a	CDEFGH			6.3a	37.3a
6	Switch	14	oz/a	CDEFGH			6.8a	26.6a
7	Elevate 50 WDG	1.5	lb/a	CDEFGH			8.0a	30.7a
8	Tanos 50 DF	10	oz/a	CDEFGH			7.3a	34.2a
9	Actigard	0.75	oz/a	CDEFGH			7.0a	29.2a
10	Miravas	10.3	fl oz/a	CDEFGH			3.8a	39.4a
LSD P=.05					627.60	1102.84	4.64	19.11
Standard Deviation					362.73	637.40	3.20	13.17
CV					126.59	255.04	43.99	39.6
Grand Mean					286.55	249.92	7.28	33.26
Levene's F					18.161	1.501	0.742	1.502
Levene's Prob(F)					0.001*	0.274	0.668	0.193
Rank X2					.	.	.	.
P(Rank X2)					.	.	.	.
Skewness					1.7063*	3.3386*	0.3988	0.2699
Kurtosis					1.8327	11.332*	-0.5701	-0.3106
Replicate F					1.199	0.958	11.533	1.504
Replicate Prob(F)					0.3871	0.4707	0.0001	0.2360
Treatment F					1.708	1.613	1.055	0.705
Treatment Prob(F)					0.2587	0.2750	0.4251	0.6989

Means followed by same letter or symbol do not significantly differ (P=.05, LSD).
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

Table 2. Comparative efficacy of nine cane blight management programs on raspberry-ranking for number of infected floricanes.

Rating Date				Jun-11-2021	Oct-15-2021	Aug-11-2021	Oct-31-2021
Rating Type				RLN/g root	RLN/g root	# infected floricanes	# infected primocane incidence
Number of Subsamples				1	1	1	1
Days After First/Last Applic.				0 0	126 58	61 6	142 74
Trt-Eval Interval				0 DA-A	126 DA-A	61 DA-A	142 DA-A
Number of Decimals				1	1	1	1
Trt No. Treatment Name	Rate	Rate Unit	Appl Code	1	2	3	4
10 Miravas	10.3	fl oz/a	CDEFGH			3.8a	39.4a
5 Luna Tranquility	16.42	fl oz/a	CDEFGH			6.3a	37.3a
6 Switch	14	oz/a	CDEFGH			6.8a	26.6a
9 Actigard	0.75	oz/a	CDEFGH			7.0a	29.2a
1 Untreated check				166.0a	717.3a	7.3a	37.7a
8 Tanos 50 DF	10	oz/a	CDEFGH			7.3a	34.2a
2 Velum Prime	237.5	g ai/ha	A	134.0a	17.0a	7.5a	36.4a
7 Elevate 50 WDG	1.5	lb/a	CDEFGH			8.0a	30.7a
3 Velum Prime	237.5	g ai/ha	AB	559.6a	15.4a	9.5a	38.0a
4 Kenja	15.5	fl oz/a	CDEFGH			9.5a	23.2a
LSD P=.05				627.60	1102.84	4.64	19.11
Standard Deviation				362.73	637.40	3.20	13.17
CV				126.59	255.04	43.99	39.6
Grand Mean				286.55	249.92	7.28	33.26
Levene's F				18.161	1.501	0.742	1.502
Levene's Prob(F)				0.001*	0.274	0.668	0.193
Rank X2				.	.	.	.
P(Rank X2)				.	.	.	.
Skewness				1.7063*	3.3386*	0.3988	0.2699
Kurtosis				1.8327	11.332*	-0.5701	-0.3106
Replicate F				1.199	0.958	11.533	1.504
Replicate Prob(F)				0.3871	0.4707	0.0001	0.2360
Treatment F				1.708	1.613	1.055	0.705
Treatment Prob(F)				0.2587	0.2750	0.4251	0.6989

Means followed by same letter or symbol do not significantly differ (P=.05, LSD).
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

Results and Discussion

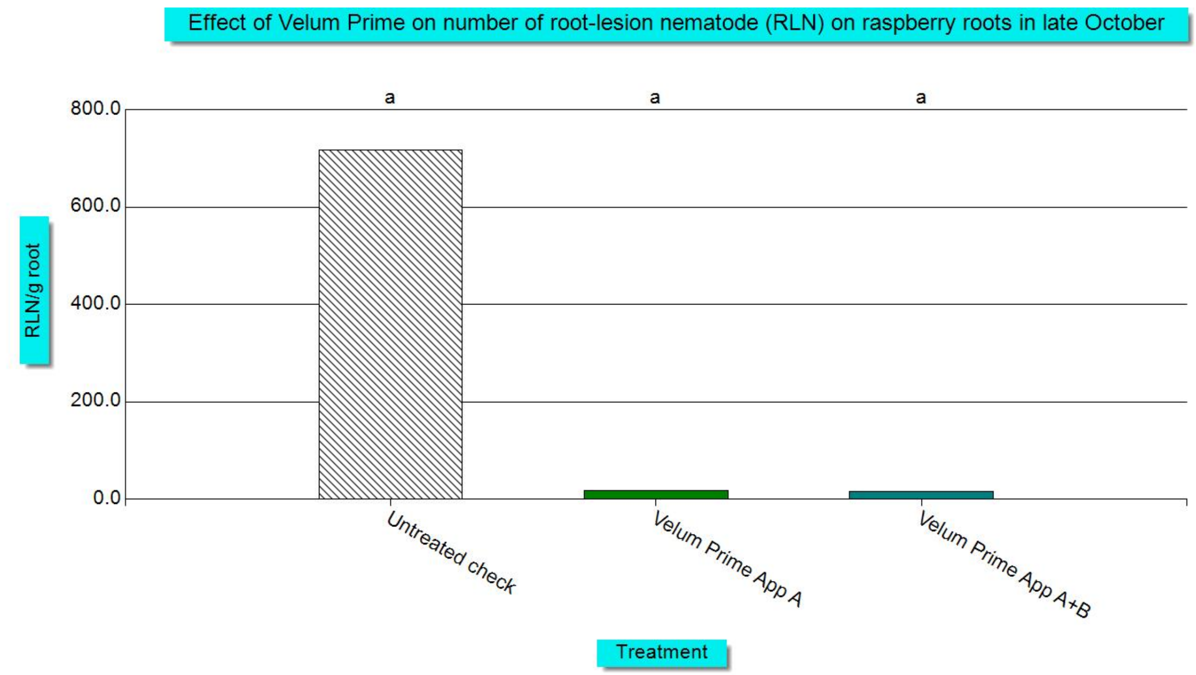
No significant differences were detected among treatments for all parameters. Treatments of Velum Prime with one and two applications showed 97.6% and 97.9% numerically less RLN/g root compared to the untreated check, respectively, in October. The RLN data are presented in data columns 1 and 2. These results indicate that application of Velum Prime for cane blight can reduce RLN. This a very important finding.

Treatments of Luna Tranquility, Switch, Actigard and Miravas showed 14%, 7%, 4%, and 48% numerically less infected floricanes as compared to the untreated check, respectively. Treatments of Velum Prime with one application, Kenja, Luna Tranquility, Switch, Elevate, Tanos, and Actigard had 3%, 39%, 1%, 29%, 19%, 9%, and 23% numerically less infected primocane incidence compared to the untreated check, respectively.

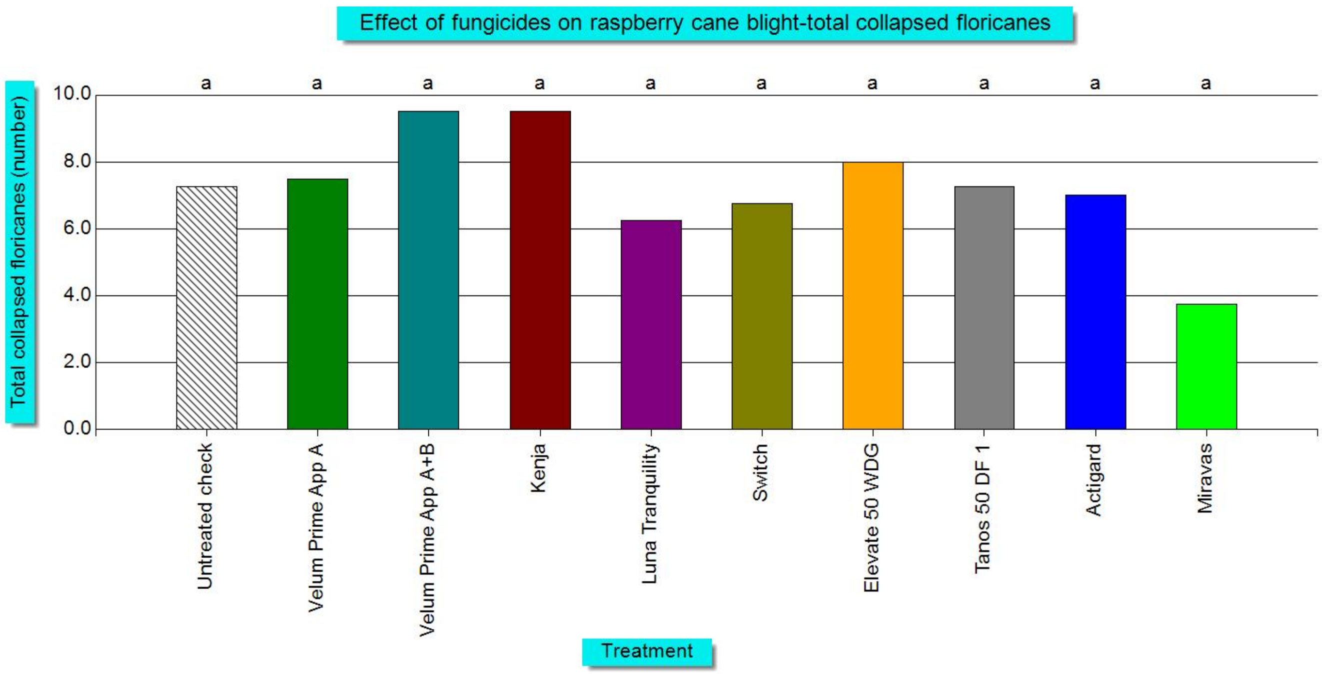
The results indicated that Velum Prime has the potential for decreasing RLN in the late season. Velum Prime did not reduce the number of infected floricanes in the mid-season and it may have the potential to reduce the infected primocane in the late season after harvest. Luna Tranquility, Switch, and Actigard reduced both the number of infected floricanes in the mid-seaon and the infected primocane after harvest, suggesting the good efficacy of suppressing cane blight in raspberry.

This trial needs to continue for one more year. It is important to continue this trial for another season to see if this year's primocanes that were treated will show up next year as floricanes with reduced infections. Additionally, we will want to confirm the reduction in root lesion nematodes based on the Velum Prime application.

Graph 1. Effect of Velum Prime on number of root-lesion nematode on raspberry roots.



Graph 2. Effect of fungicides on raspberry cane blight-total collapsed floricanes. The evaluation was on August 11, 2021.



Graph 3. Effect of fungicides on raspberry cane blight-primocanes infection incidence. The evaluation was on October 31, 2021.

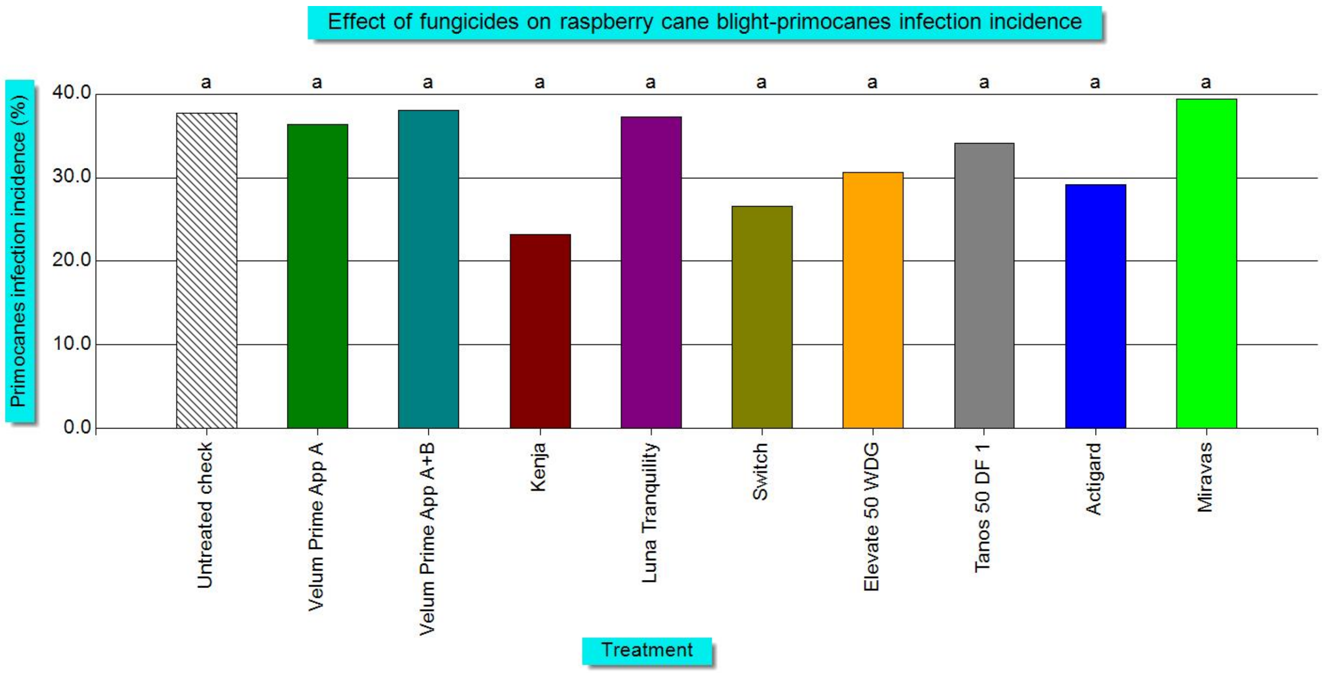


Photo 1. Application A using drip on June 11.

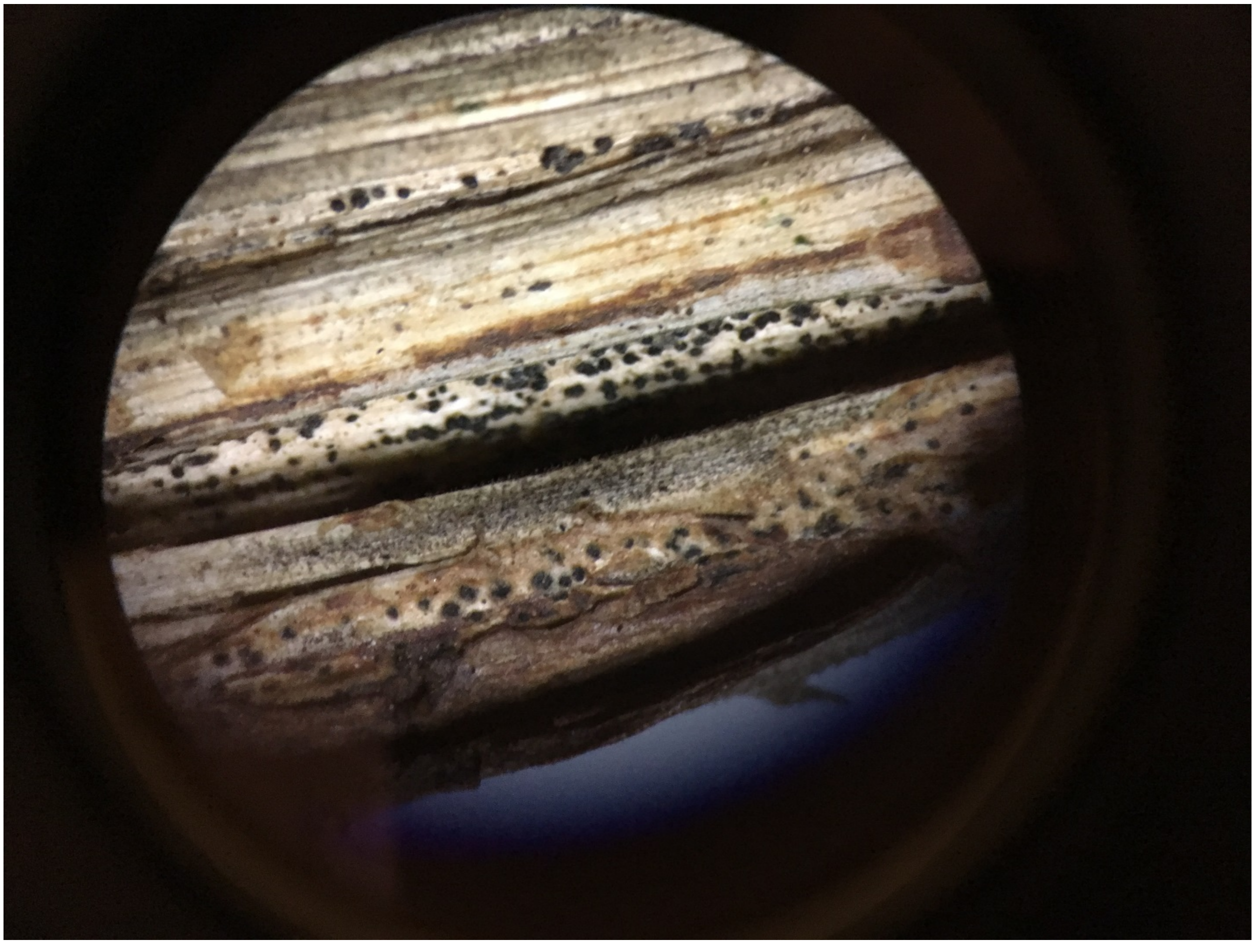
Photo 2. Application F using over the row sprayer on August 5, 2021.

Photo 3. Raspberry plot photo taken on July 3 (left, application C) and July 15 (right, application D).

Photo 4. Cane blight lesions on July 15 (left, application D) and July 27 (right, application E).

Photo 5. Close-up photo for raspberry cane blight lesions.

Photo 6. Close-up photo for cane blight pycnidia.



Project Proposal to WRRC **Proposed Duration:** 1 Year

Project Title: Control of Cane Blight in Red Raspberries

PI: Alan Schreiber
Organization: Agriculture Development Group, Inc.
Title: Researcher
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Cooperators: Lisa Jones, Northwest Plant Company, Lynden.
Tom Walters, Walters Ag Research, Anacortes

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

Total Project Request: Year 1 $10,000

Other Funding Sources: We have submitted a proposal to the Washington State Commission on Pesticide Registration for $16,000.

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 set back on the project as the same applications needs to be made to the same plots to both the primocane and the subsequent year's floricane to effectively evaluate the treatment's efficacy. 2021 was the third year of the project and the second year of treatments to the same plots. Overall, efficacy results against cane blight were disappointing with only one treatment providing much control. However, the use of Velum Prime for cane blight control using timings for nematode control did not provide a great deal of reduction in root lesion nematode numbers.

Justification and Background: Cane blight, which is caused by the fungus *Kalmusia coniothyrium,* occurs on a wide range of crops including raspberry, blackberry and roses, and was only recently recognized as a major pest on Washington red raspberries. Cane blight infection requires a wound, such as those that occur during machine harvest, to infect a plant. Infections commonly originate on primocanes during summer. Shortly after infection the fungus colonizes vascular tissue. The fungus will produce small black pimple-like spore producing bodies in the fall and overwinter on the cane. The fungus will continue to grow in the spring and it will slowly girdle the cane. The girdled cane will start to wilt and collapse during early fruit development. Symptoms will develop quicker during hot and dry weather. Uninfected canes and roots are not affected. The fungus can also live on the dead tissue such as cane stubble or debris in the soil. Cane blight rarely is a problem in hand-harvested fields. Rain or overhead irrigation during harvest has increased disease incidence because spores are disseminated in splashing water. Young canes are more rapidly infected, while older canes of raspberry plants 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 very effective. One Washington raspberry grower found that alternating Tanos with Switch (Group 9 and 12) and Pristine (Group 7 and 11) seemed to reduce cane blight.

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

Depending on 2022 research results and feedback from the industry, this could be the final year for this project.

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

Objective 1. Collect information on disease biology – including developing a growth curve of the cane blight fungus with respect to temperature to help us better understand disease progression since severity is much greater with warmer temperatures.

Objective 2. Generate data on fungicide efficacy against cane blight.

Objective 3. Generate efficacy data of Velum Prime against root lesion nematodes.

Procedures: A fungicide efficacy trial will be repeated in 2022 in the same location as 2020 and 2021 in a WakeHaven field that has a significant infection of cane blight. The trial is set up as a randomized complete block design with four replications. Plot size would be approximately 10 feet by 30 feet. The treatments in the 2021 trial were Velum Prime applied a month before harvest by drip and a second treatment at one day before harvest by drip. Then Kenja, Luna Tranquility, Switch, Elevate, Tanos and Actigard were applied as a directed spray to the base of the plant. The product choices were made in consultation with the Berry Pathology Technical Working Group that is made up of growers, crop advisors, university researchers and extension specialists, agrichemical companies and others with an interest in berry pathology. The Velum Prime treatment applied at one month before harvest begins to mimic an application made for root rot control. Actigard is a stimulated activated resistance (SAR) product. Other than Miravis, all treatments are registered on raspberry. Miravis is in the process of being registered on raspberry.

We plan to largely do the same treatments in 2022 as in 2020 and 2021. The Actigard treatments will start earlier that the other treatments and also the applications would be made on the entire plants. The remaining foliar applications would be a directed spray towards the base of the plant. Foliar applications would start just prior to harvest, and a total of six applications would be made for the foliar fungicides until harvest is over. An over the row sprayer would be used to make the applications. The selection of fungicides for cane blight will have implications for *Botrytis* control. Therefore, in addition to cane blight, the trialists will evaluate for *Botrytis* and any other diseases, such as yellow rust, if appears. Application of products such as Pristine, Switch and Luna Tranquility for cane blight also has implications for *Botrytis* resistance management strategies.

Dr. Jones will have the lead on collecting information on the biology of this disease species. Funding this project is an excellent mechanism for harnessing the expertise of Dr. Jones for the greater benefit of the Washington raspberry industry.

Anticipated Benefits and Information Transfer:

Our goal is to develop a set of recommendations for control of cane blight on raspberry and assess the implications cane blight applications will have for *Botrytis* control programs. This information would be provided to growers through WRRC disseminated information, at the Washington Small Fruit Conference (as Schreiber did at the 2021 SFC) and at grower meetings.

Budget:	**2022**
Salaries	3,000
Operations	650
Travel	500
Contract Research	4,000
Benefits	1,850
Total	$**10,000**

The funds for Contract Research are for chemical applications by Tom Walters. Northwest Plant will donate travel 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.

2022 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

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

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

PI:
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Co-PI:
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Research Plant Pathologist
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Cooperators:

Year Initiated 2022 Current Year 2022 Terminating Year 2023

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Anticipated Benefits and Information Transfer:

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

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

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

	2022	2023	2024
Salaries[1/]	$3,500	$3,500	$
Time-Slip	$ 500	$ 500	$
Operations (goods & services)	$1,500	$1,500	$
Travel[2/]	$ 345	$ 345	$
Meetings	$	$	$
Other[3/]	$ 600	$ 600	$
Equipment	$	$	$
Benefits[4/]	$	$	$
Total	**$6,445**	**$6,445**	**$**

Budget Justification

1/ Walters, 0.035% FTE, benefits included.

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

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

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

2022 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

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

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

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

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

Year Initiated 2022 Current Year 2021 Terminating Year 2024

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

Other funding sources: We are submitting a parallel proposal to the Washington State Commission on Pesticide Registration (WSCPR).

Description:

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

Justification and Background:

Botrytis cinerea, the causal agent of fruit rot and gray mold, results in serious losses from pre- and postharvest diseases in over 200 economically important crop hosts worldwide (14). Infection of raspberry flowers and berries can directly reduce yield and berry quality (2, 8, 10) in all locations where red raspberries are grown, including British Columbia, Idaho, Oregon, and Washington.

Application of synthetic fungicide sprays are the primary management strategy for control of gray mold on raspberries and other small fruit crops. *Botrytis* is a "high risk" pathogen for the development of fungicide resistance owing to its rapid lifecycle, genetic diversity, high fecundity (production of millions of spores), and spread by wind (1, 5, 6, 12, 16). Resistance to several fungicide classes defined by Fungicide Resistance Action Committee (FRAC), including demethylation inhibitors (DMIs, FRAC 3), succinate dehydrogenase inhibitors (SDHIs, FRAC 7), and quinone outside inhibitors (QoIs, FRAC 11) has been reported worldwide (5, 15, 18, 19). The increasing prevalence of fungicide resistance in *Botrytis* has become a serious limitation for effective disease control. An increasing number of isolates with resistance to not only a single fungicide but also to multiple fungicides of different chemical classes have been reported (3, 11, 17). Fungicide resistance frequencies have been shown to differ between years, crop hosts, locations, and among different strains of *Botrytis* spp. (3, 10). Previous studies have also shown high levels of genetic variation for *Botrytis* among fields and even on a single plant (4). However, studies of population variability in relation to fungicide resistance profiles showed limited to no association with the population structure (3, 7). Genetic variability of *Botrytis* isolates within a population may influence the development of fungicide resistance, it is also likely that environmental variation (i.e…locations, hosts, synthetic spray applications) are an important driver for observed and persistent fungicide resistance. Because different *Botrytis* spp. can exhibit differences in fungicide resistance profiles, it is critical to understand the pathogen population structure in different environments. The characterization of both fungicide resistance profiles and linking these profiles to genetic diversity among populations will allow development of better disease management strategies.

There is limited information about *Botrytis* ssp. population structure and genetic diversity in red raspberry fields from Washington and understanding adaption to the host is a key issue for "generalist" pathogens, like *Botrytis*, particularly as it relates to disease management. While fundamental research has been conducted by other research groups supported through the Washington Red Raspberry Commission, which monitored fungicide resistance development in-fields using tools such as molecular markers, this proposal is independent and compliments the work conducted by the other research groups. The research addressed in this proposal focuses on using microsatellite markers, previously developed for gray mold of grape and *Prunus* to investigate the genetic diversity of *Botrytis* spp. and fungicide resistance status currently existing in the northwestern Washington red raspberry fields. By observing changes in the population structure as it relates to fungicide resistance, we are able to monitor pathogen stability in-fields in response and adaption to different environments

Relationship to WRRC Research Priority(s):

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

Funding for 2022 will address: construction, installation, and monitoring of *Botrytis* spore trap stations; collection of *Botrytis* samples from fields; pure culture production; fungicide sensitivity assays; begin conducting DNA isolations and measure nucleic acid properties.

Procedures:

We will sample approximately five conventionally- and organically- managed red raspberry fields in northwestern Washington (Whatcom and Skagit Counties) after consulting with grower cooperators and crop consultants. Metadata pertaining to each field such as GPS location, cultivar, age of the planting, and fungicide application history will be collected from the grower. Manual sampling of cane, flower, or ripe berries will be conducted twice a year (early season and late season). The spore traps with impaction rods will be placed in red raspberry fields and serviced and monitored routinely throughout the entire growing season and removed during the winter months. Manually collected samples with *Botrytis*-like conidiophores will be transferred to PDA, and asymptomatic samples will be incubated to induce sporulation. All isolates will be single spored to obtain pure cultures. *Botrytis* conidia collected from the spore trap impaction rods will be subjected to DNA extractions. All *Botrytis* spp. will be identified to the species level by PCR using standard molecular markers (11, 13). Fungal stock cultures will be made and stored at -80°C until further use.

Pure fungal stock cultures obtained in the described methods above, will be used in a modified broth assay (Alex Wong, *unpublished*) to determine fungicide sensitivity based on relative turbidity. In brief, fungal spore suspensions (1×10^5 spores/mL) in 2% malt extract broth (MEB) will be collected from sporulating cultures of *Botrytis*. The technical-grade fungicides will be suspended and diluted in distilled water to make stock solutions. Fungicide stocks will be aliquoted into 96-well plates in 10 µL aliquots. Each 96-well plate will test for two fungicides, five concentrations per fungicide plus a negative control, with the ability to examine up to seven distinct isolates and include a non-template control. Spore suspension aliquots of 190 µL will be pipetted into each well containing 10 µL fungicide stocks. The optical density (OD) at 495nm of each well will be measured using a multi-well plate reader. OD measurements will be taken every 12 hours over a period of 96 hrs. Measurements will be normalized using the OD for the MEB negative control. The experiment will be repeated twice. Each isolate will be classified as sensitive or resistant based on relative turbidity compared to the control.

Technical-grade fungicides containing a single active ingredient and belonging to multiple FRAC groups will be added to malt extract broth. Specifically, we will test sensitivity to at least the following fungicides and associated FRAC classes: myclobutanil and prothioconazole (FRAC3), boscalid, fluopyram, isofetamid -"Kenja", and, fluxapyroxad (FRAC7), cyprodinil and pyrimethanil (FRAC9), and trifloxystroblin (FRAC11), and compare efficacy of common mix sprays such as Luna Tranquility and Luna Sensation. Salicylhydroximic acid (SHAM) will be added to media to inhibit the pathogen's alternative oxidase pathway when testing for resistance to FRAC 11. Previously developed discriminatory fungicide dosages will be used for conducting fungicide sensitivity assays (16).

Nine previously developed polymorphic microsatellite makers (3) will be used to assess allelic differences in *Botrytis* isolates. In brief, a three-primer method consisting of a fluorescently labeled forward primer tag will be used in conventional PCR, conducted on extracted DNA of spores collected manually, and from impaction rods. PCR amplicons will be subjected to fragment analysis and processed at the USDA-ARS HCRU in Corvallis, OR. Allele fragment size data will be analyzed using computer software *Geneious*. Population analysis and genetic diversity will be calculated using *Poppr* with in RStudio. Pairwise population genetic identify among and between populations based on location and fungicide resistant frequencies will be calculated using the software *GenAlEx.*

***Project will span approximately 3 yrs.**
2022- construction and installation of spore traps, collection of samples, pure culture production, fungicide sensitivity assays, DNA extractions
2023- PCR, Fragment analysis
2024- Genetic diversity and population data analysis

Anticipated Benefits and Information Transfer:

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

References:

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

	2022	2023	2024
Salaries[1/]	$0	$	$
Time-Slip	$4,200	$	$
Operations (goods & services)	$14,008	$	$
Travel[2/]	$1,792	$	$
Meetings	$0	$	$
Other	$0	$	$
Equipment[3/]	$0	$	$
Benefits[4/]	$0	$	$
Total	**$20,000**	**$**	**$**

Budget Justification

[1/] One time-slip employee ($4,200 per year) – A time-slip employee will work for 7 weeks at a rate of $15.00 per hour for 40 hours per week (including benefits) This person will assist with field sampling, media preparation, and culturing of isolates.

[2/] We are requesting funds for travelling to grower fields in WA to collect berry samples during the growing season. Mileage = $1,792 (40 trips X 80 miles/trip X $0.56/mile).

[3/] None requested

[4/] None requested

SOILS

2022WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

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

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

PI: Inga Zasada
Organization: USDA-ARS
Title: Research Plant Pathologist
Phone: 541-738-4051
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Address: 3420 NW Orchard Ave.
City/State/Zip: Corvallis, OR 97330

Co – PIs:
- Lisa DeVetter, WSU-NWREC
- Tom Walters, Walters Ag Research

Cooperators: Deirdre Griffin and Gabriel LaHue (WSU-NWREC), Jeff DeLong and Jerry Weiland (USDA-ARS), , Rebecca Bunn (Western Washington University), Chris Benedict (WSU-Whatcom Co.), Suzette Galinato (WSU), Tim Purcell (Trident), Eric Gerbrandt (BC), Henry Bierlink (WA red raspberry commission), Julie Pond (Peerbolt Consulting), industry partners including Randy Honcoop, Kevin Berendsen, Harb Baines, Allen Brown, Brad Radar, Adam Enfield and any others as they express interest.

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

Total Project Request: $

Other funding sources: No

Description:
The Washington Red Raspberry Commission has long had “soil health” as one of the industry’s priorities. In the 2021 priorities, soil health is listed as a #2 priority under “understanding soil ecology and soil borne pathogens and their effects on plant health and crop yields.” Many of the other priorities outlined by the commission are related to soil health, because a healthy soil has consequences on all aspects of a healthy plant including the ability to withstand extreme climatic events, defend against pests, and produce high quality fruit. While many researchers in the region have dabbled in aspects of soil health in raspberry over the years, and there was the “EcoRaz” effort to bring industry and researchers together, there has never been an organized vision on how to address this topic experimentally to produce information of value to the raspberry industry. This one year proposal will strive to bring together researchers and industry representative to create a strategic vision as to how we might address soil health in raspberry. Outcomes will include increased industry knowledge of soil health, a team approach to

conducting research in soil health, and the framework to pursue external funding to support long-term research efforts in soil health in raspberry.

Justification and Background:

Talk with farmers that grew raspberries 30 years ago and they will talk about how plantings lasted 10-15 years or longer. Now a planting will last 5-7 years at the most increasing the price of farming due to the heavy investment in infrastructure needed for raspberry production with a cost of establishment of at least $10,000-$13,000/acre (Galinato and Devetter, 2016). There certainly isn't one culprit that can be attributed to this decline in production lifespan, with many different factors at play including: simply wanting to change variety to meet market demands, crumbly fruit from virus, and/or declining yields. However, there is probably one factor that at least contributes to reduced production lifespan, and that is soil health. Soil health is defined as "the capacity of a soil to function as a vital living ecosystem to sustains plants" (NRCS, 2021). To be honest, raspberry production is hard on soil due to repeated planting of raspberry in the same soil, widespread use of pre-plant fumigation, and high intensity of equipment moving through the field (e.g., tillage, compaction from harvesters, etc.).

Soil health is a popular concept that seeks to incorporate soil biology into soil management frameworks. At the core of soil health is the ability of soils to maintain their optimal function to meet specific context-dependent goals. There is a recent effort in Washington to address soil health across production systems in the State, called the WA Soil Health Initiative (WSU-Soil-Health-Roadmap-Nov-2021-Version.pdf). Some of the primary goals of this effort are to:

- Develop universal low-cost soil health measurement tools and set of metrics.
- Improve knowledge of soil health.
- Maintain soil organic matter with increases of levels in the future.
- Communicate the concept and value of soil health by the general public.

One emerging question is whether raspberry production should be part of this conversation and whether the State legislator or other entities will invest funds in addressing soil health issues in raspberry. We propose to bring the raspberry industry and research community together to have an honest discussion of how to address soil health in raspberry production.

Relationship to WRRC Research Priorities:

This project addresses the #2 priority of understanding soil ecology and soil borne pathogens and their effects on plant health and crop yields.

Objectives:

The objective of this project is to bring researchers and industry representatives together to create a vision to addressing soil health in raspberry.

Procedures:

The approach to bringing people together to discuss soil health in raspberry production will be approached in three phases.

Phase I: In the spring of 2022, researchers interested in soil health in raspberry and industry representatives with a similar interest will come together in a one-day meeting. At this meeting, up to four external participants will be invited including: a grower from another perennial production system who is applying concepts to improve soil health; a researcher conducting long-term research in another perennial production system; a State representative from Whatcom County; high level administrator from WSU. These invited attendees will be present for the following reasons, respectively: to provide a growers perspective on modifying a perennial production system to improve soil health; to describe the benefits and challenges of conducting soil health research; to deliver a voice in the WA state legislator (Senator Doug Eriksen or Representatives Alicia Rule and Sharon Shewmake) o support soil health research in raspberry production; and, to find an advocate at WSU to support this effort.

The format for this meeting will be informal and allow for interaction among participants. The PIs/co-PIs on this proposal will outline the agenda for the day, invited speakers will provide their perspectives, and then attendees will work in small groups to facilitate conversations and ideas.

Phase II: Over the course of the summer of 2022 researchers interested in soil health will organize breakfast meetings with industry representatives to discuss soil health and how the raspberry production system might be modified to improve soil health. At least 5 breakfast meetings will be held.

Phase III: Individuals who continue to be interested in concepts and ideas related to improving soil health in raspberry will meet in fall of 2022 to draft a long-term vision to address the problem. At the end of the meeting the following aspects will be addressed:

- Draft plan of a long-term research trial that addresses management opportunities to improve soil health in raspberry production systems.
- A plan for where to find funding for such an effort. Specifically, is there a way to obtain funding from the WA State Legislature as part of the WA Soil Health Initiative?
- Compile a list of participants interested in supporting soil health research and outreach collaboratively in the future.

Anticipated Benefits and Information Transfer:
First, everyone involved will become more familiar with the concepts underlying soil health by participating in workshops where growers and researchers from other production systems discuss their perspectives. Second, a long-term vision or road map will be developed on how to address soil health in raspberry from the perspectives of research, funding and implementation. Finally, meetings between researchers and industry representative in formal and informal settings will continue to foster cooperation.

References:
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NRCS, 2021. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/.

Budget:

Budget Item	2022
Invited speakers ($1,000 honorarium/speaker)	$4,000
Breakfasts ($75/breakfast)	$375
Operations (food, goods, services) for 2 meetings	$500
Travel of remote participants ($200/participant up to 4 trips)	$800
Total	**$5,675**

Budget Justification
Invited speakers – We are not sure that all invited speakers will be able to accept honorariums. If these funds are not all expended they will be returned to WRRC.

Operations – Lunch and snacks will be provided during the meetings. Other consumables will include printed materials, etc.

Travel – Some participants are not located in the Skagit/Whatcom area so funds are requested to offset travel of these participants. Additionally, USDA researchers cannot accept honorarium but their travel can be paid.

Washington Red Raspberry Commission Progress Report for 2021

Project No: 4499-1208
Title: Measuring and Mitigating Soil Compaction in Raspberry Alleyways

Personnel:
Principal Investigator: Deirdre Griffin LaHue, Assistant Professor of Soil Quality and Sustainable Soil Management
Co-Principal Investigators: Haly Neely, Chris Benedict, Gabriel LaHue
Other personnel: Navdeep Singh (Postdoc with Dr. LaHue), Dylan Mullins (M.S. Student with Dr. Neely), Betsy Schacht (Scientific Assistant)

Reporting Period: 2021 (No funds were requested for 2021, but work on this project continued this year due to challenges in 2020)

Accomplishments:
The original objectives of this project were to help red raspberry growers and researchers better understand the extent to which compaction is an issue, including where in the alleyway compaction is highest, what equipment and practices are currently being used to manage it, and how drainage issues in alleyways are related to soil compaction. This project was funded by the WRRC in 2020, and we made progress toward accomplishing these goals during that year, but equipment issues caused challenges with the measurements, as described below and in the 2020 report. We did not request additional funding in 2021 but did continue work on these objectives.

Brief summary of 2020 activities: In summer 2020, we worked with 5 red raspberry growers in Whatcom County to identify field sites representing the range of soil textures, planting ages, alleyway practices (e.g., cover cropping, tillage) and field histories of raspberry fields in the region. We used a Geonics EM-38 apparent electrical conductivity (EC) device to map the soil in 10 fields to understand within-field variability in soil properties correlating with soil texture and moisture content, which allows us to make more informed choices when selecting sampling points. In early August 2020, after harvests were complete (at maximum compaction), we attempted to take compaction measurements using a steel penetrometer mounted on a hydraulic ATV-mounted Giddings machine (Figure 1a). We set out to take measurements in the center and edge (near beds) of alleys in each field along with soil cores to measure soil texture, moisture, and organic matter content. We also conducted measurements of field saturated hydraulic conductivity (similar to infiltration; Figure 1b). The level of compaction was very high to the extent that the steel penetrometer began bending after several measurements, and after attempting other approaches, we concluded that we would achieve the best dataset by redoing the measurements in 2021 with a stronger penetrometer.

2021 activities: A reinforced, thicker steel penetrometer was manufactured in late 2020, and in March 2021 we set out to conduct compaction measurements and test the penetrometer at a time when we expected the soil to less compacted (compared to post-harvest). We chose to focus on the effects of field age on compaction and worked with 4 red raspberry growers in Whatcom County to identify paired fields (one field that was first year-bearing and one that was >7 years in production) within each farm. Each pair had a similar soil texture to remove that as a confounding factor in the comparisons of field age. Many of the fields selected for 2021 were fields we had also mapped in 2020.

Unfortunately, the new, reinforced steel penetrometer still had issues with bending while taking measurements, likely due to torquing occurring with the anchor and movement of the ATV (which is lighter than equipment this is traditionally used with). We decided to adjust our approach and use a hand-held dynamic cone penetrometer, in which a weight is dropped repeatedly to move the penetrometer tip into the soil, and the depth is recorded with each drop. Measurements were taken within wheel tracks near the interface of the bed and alleyway. We chose two locations per field and completed 3 independent measurements at each location. Additionally, we took intact soil cores (3 at each of 2 locations) from the soil surface to measure lab hydraulic conductivity (Ksat; a proxy for infiltration) to understand the effects on water movement. More than 50% of the cores have been analyzed using a "constant head" methodology, which is appropriate for soils with higher Ksat (where water moves more quickly). Some of the cores had Ksat below the cut-off and will need to be analyzed using a "falling head" methodology. We have recently acquired an apparatus that will perform these falling head Ksat measurements, and all cores will be analyzed in the coming months.

Preliminary Results:

Saturated hydraulic conductivity and penetration resistance data has been summarized for paired fields from two farms. We found that in both cases, younger fields had higher Ksat than older fields (Figure 2), indicating that water will infiltrate more easily into the soil of younger fields. We also found that older fields were slightly more compacted at the soil surface (which likely explains differences in water movement), but that the older field in Farm 1 was less compacted below 10 inches, perhaps due to a longer history of deep ripping (Figure 3). In Farm 2, there were no significant differences in compaction between the younger and older field at depth. Additional results will be available when the remaining cores can be analyzed with the constant head Ksat methodology. We will also summarize compaction data from the remaining farms.

Our ultimate goal is that this compaction assessment will inform future experiments to test and develop improved compaction management strategies, equipment, and recommendations for raspberry growers to mitigate issues that compaction may cause related to water drainage and plant health. In the coming year, we will engage in conversations with other researchers and red raspberry growers to think holistically about soil compaction, soil health, and their interactions with soilborne diseases and plant health, and to identify research questions and methods that can help us to address these issues.

Publications:
Results to date were presented at the Washington Small Fruit Conference on December 2, 2021. Once we are able to complete measurements and analysis, we plan to publish results in a peer-reviewed journal, such as *Geoderma* or *HortTechnology*.

Appendix

Figure 1. Photographs showing how measurements were conducted for (a.) penetration resistance and (b.) field saturated hydraulic conductivity.

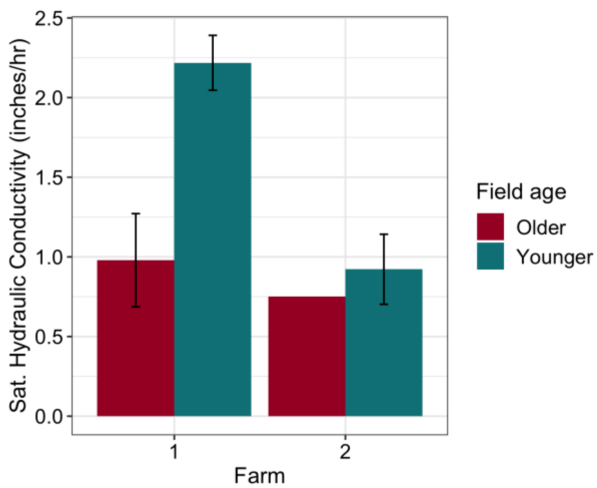

Figure 2. Saturated hydraulic conductivity (Ksat) in inches/hour from younger and older paired fields at two farms. Bars show the mean with error bars representing standard error of 6 in-field replicates. Higher Ksat is indicative of faster water movement into the soil.

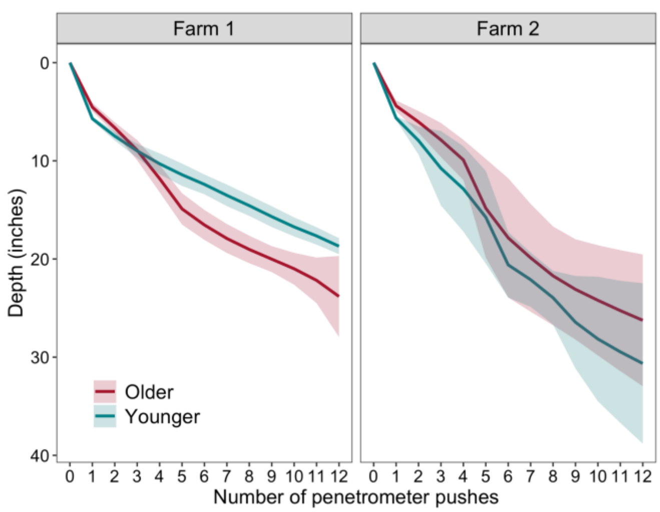

Figure 3. A depth profile of penetration resistance from younger and older paired fields at two farms. The method used measured the depth obtained with consecutive drops of a weighted penetrometer. Lines represent the average depth of 6 measurements per field, and the shaded area shows the 95% confidence interval. If shaded areas do not overlap, these are considered significantly different.