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

WRRC Office

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2015 Production 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
- Mite management
- Fruit rot including pre harvest, post harvest, and/or shelf life.
- Soil fumigation techniques and alternatives to control soil pathogens, nematodes, and weeds.
- Management options for control of the Spotted Wing Drosophila

#2 priorities

- Understanding soil ecology and soil borne pathogens and their effects on plant health and crop yields.
- Maximum Residue Limits (MRL) – residue decline curves
- Root weevils
- Labor saving cultural practices including A/Y systems and mechanical pruning and tying techniques.
- Nutrient/Irrigation management

#3 priorities

- Vertebrate pest management
- Viruses/crumbly fruit, pollination
- Weed management
- Foliar & Cane diseases – i.e. spur blight, yellow rust, cane blight, etc.
- Cane Management including suppression

Of Note:

- Pest Management as it affects Pollinators
- Season extension: improve viability of fresh marketing

PAGE	PROJECT TITLE	RESEARCHER (S)	REQUEST of WRRC	WRRC Draft	Other Funding	Source	WRRC Approved
	PLANT BREEDING						
3	Developing the Genomic Infrastructure for Breeding Improved Black Raspberries	Finn	$1,000				
10	Cooperative raspberry cultivar development	Finn	$7,000				
24	Red Raspberry Breeding	Moore	$75,000				
30	Red Raspberry Cultivar Development	Dossett	$12,000				
38	Regional on-farm Trials of Advanced Raspberry Selections	Peerbolt	$11,200				
	ENTEMOLOGY						
44	Development of Biologically-based RNAi Insecticide to Control SWD	Choi	$10,000				
48	Combining miticides and SWD controls into a season long effective program	Tanigoshi	$11,657				
	WEEDS						
55	Testing herbicides for weed control in newly-planted red raspberries	Miller	$2,936				
	PHYSIOLOGY						
63	Comparison of Alternate- and Every-Year Production in Summer-Bearing Red Raspberry	DeVetter	$8,958				
67	Impacts of Alleyway Cover Crops on Soil Quality and Plant Competition	DeVetter	$8,157				
72	Raspberry trellising demonstration plot for development of automation technologies	Karkee/Tarara	$63,731				
	PATHOLOGY/VIROLOGY						
80	Management of Fungicide Resistance in Botrytis in WA Berries	Schreiber	$12,000				
110	Biology of *Botrytis* causing fruit rot of red raspberry and fungicide resistance	Peever	$22,615				
118	Evaluation of Raspberry Bushy Dwarf Virus strains	Moore/Lanning	$6,990				
	SOILS						
123	Integration of Factors to Improve Soil Health in Red Raspberry Production	Benedict	$8,478				
131	Incidence and Detection of *Verticillium dahliae* in Red Raspberry Production Fields	Weiland/Benedict					
133	Fungicide Sensitivity of *Phytophthora rubi*	Weiland	$5,265				
138	Humic Acid Amendments in Promoting Root Health and Productivity	Bryla	$6,630				
144	Evaluating soil fumigation alternatives	Walters/Zasada	$8,643				
149	Fine-tuning Vydate applications in red raspberry for *Pratylenchus penetrans* control	Zasada/Walters					
153	Efficacy of Drip-applied Vydate for newly planted raspberry	Walters/Zasada	$1,630				
157	Soil ecology of red raspberry produced under different production regimes	Zasada/Dunlap	$14,000				
	Future Projects						
	Total Production Research		**$297,890**	**$0**	**$0**		**$0**
	Research Related	WRRC expenses	$5,000	$5,000			
	Small Fruit Center fee		$2,500	$2,500			
	TOTAL		**$305,390**	**$7,500**			**$0**
	2015 Research Budget		$286,531				

Washington Red Raspberry Commission Progress Report

Title: Support of SCRI Proposal "Developing the Genomic Infrastructure for Breeding Improved Black Raspberries"

Personnel:
Co-Project Directors
Jill Bushakra, USDA-ARS, Post Doc; Chad Finn, USDA-ARS Research Geneticist; Nahla Bassil, USDA-ARS Research Geneticist; Jungmin Lee, USDA-ARS Research Chemist
Commercial growers in Oregon, Washington, North Carolina, and New York

Reporting Period: 2014

Accomplishments:
We completed propagation of the mapping populations and either shipped them to locations in the eastern US or planted them at our location and the commercial grower locations in the Pacific Northwest. All populations established well with almost no plant losses. We began the discussion on phenotyping protocols. The USDA-ARS NCGR group isolated DNA from parents and each individual in the mapping populations. The OSU CGRB generated transcriptome sequences from leaves, stems, canes, green berries, red berries, and ripe berries of 'Jewel'. These RNA sequences will be assembled next and then used to develop additional markers to populate the black raspberry linkage map. We've constructed a preliminary genetic linkage map and are using this to further assemble the draft genome. We have presented our results at several international and regional conferences. Our summer intern assisted in the collection and analysis of several fruit and growth traits at the Corvallis location and screened more than 200 markers for potential use in the mapping project.

Results:
We are on track. Research plots have been established and lab work is progressing. We are gathering phenotypic data on each individual plant at the different locations.

Publications:

Bassil, N., M. Dossett, B. Gilmore, T. Mockler, S. Filichkin, M. Peterson, K. Lewers, and C. Finn. 2012. Developing genomic resources in black raspberry. Sixth Rosaceous Genomics Conference, Trento, Italy. (Abstract).

Bushakra, J., N. Bassil, M. Dossett, B. Gilmore, T. Mockler, D. Bryant, S. Filichkin, J. Weiland, M. Peterson, C. Bradish, G. Fernandez, K. Lewers, J. Graham, and C. Finn. 2012. Black raspberry genomic resource development. Plant and Animal Genomics, San Diego, CA. (Abstract).

Bushakra, J.M., N. Bassil, M. Dossett, T. Mockler, D. Bryant, M. Peterson, C.E. Finn. 2013. Developing a genotyping by sequencing protocol for linkage map construction in black raspberry. American Society of Horticultural Scientists Annual Meeting, Palm Desert, CA (Abstract).

Publications 2013/2014

Bassil N, Gilmore B, Hummer K, Weber C, Dossett M, Agunga R, Rhodes E, Mockler T, Scheerens JC, Filichkin S, Lewers K, Peterson M, **Finn CE,** Graham J, **Lee J,** Fernández-Fernández F, Fernandez G, Yun SJ, Perkins-Veazie P. 2014. Genetic and developing genomic resources in black raspberry. *Acta Hort.* 1048:19-24.

Lee J. 2015. Sorbitol, *Rubus* fruit, and misconception. *Food Chem.* 166:616-622.

Lee J, Dossett M, **Finn CE**. 2014. Mistaken identity: clarification of *Rubus coreanus* Miquel (bokbunja). *Molecules- special Anthocyanin issue* 19:10524-10533.

Lee J. 2014. Marketplace analysis demonstrates quality control standards needed for black raspberry dietary supplements. *Plant Foods Human Nutr.* 69:161-167.

Lee J, Dossett M, **Finn CE.** 2014. Anthocyanin rich black raspberries can be made even better *Acta Hort.* 1017:127-133.

Lee, J, Dossett, M, **Finn, CE**. 2013. Anthocyanin fingerprinting of true bokbunja (*Rubus coreanus* Miq.) fruit. *J Funct Foods*. 5:1985-1990.

Paudel L, Wyzgoski FJ, Giusti MM, Johnson JL, Rinaldi PL, Scheerens JC, Chanon AM, Bomser JA, Miller AR, Hardy JK, Reese RN. 2014. NMR-based metabolomic investigation of bioactivity of chemical constituents in black raspberry (*Rubus occidentalis* L.) fruit extracts. *J Agric Food Chem.* 62:1989-1998.

Paudel L, Wyzgoski FJ, Scheerens JC, Chanon AM, Reese RN, Smiljanic D, Wesdemiotis C, Blakeslee JJ, Riedl KM, Rinaldi PL. 2013. Non-anthocyanin secondary metabolites of black raspberry (*Rubus occidentalis* L.) fruits: Identification by HPLC-DAD, NMR, HPLC-ESI-MS and ESI-MS/MS analyses. *J Agric Food Chem.* 61:12032-12043.

Additional Publications (PDs in bold font):

Lee J, Dossett M, **Finn CE.** 2014. Chemotaxonomy of black raspberry: deception in the marketplace? Polyphenols Communications 2014 (Proceedings of XXVIIth International Conference on Polyphenols, Nagoya, Japan). 2014:347-348. (Conference Proceedings)

Lee J, Dossett M, **Finn CE**. 2013. Black raspberry: Korean vs. American. http://www.black-raspberries.com (Other)

Lee J, Dossett M, **Bassil NV, Finn CE**. 2013. A black berry that is not a blackberry. http://www.black-raspberries.com (Other)

Presentations (PDs and presenters in bold font):

Bradish CM, **Bushakra JM**, Dossett M, **Bassil NV, Finn CE**, **Fernandez GE** (presenter). Poster. Genotyping and phenotyping heat tolerance in black raspberry (*Rubus occidentalis* L.). International Horticulture Congress (IHC), Brisbane, Australia. August 2014.

Bradish C (presenter), Fernandez G, **Bushakra J**, Perkins-Veazie P, Dossett M, **Bassil N**, **Finn C**. North Carolina's role in a nationwide effort to improve black raspberry. Oral presentation. Southern Region – American Society for Horticultural Science (ASHS), Dallas, TX, February 2014.

Bradish C (presenter), Fernandez GE, **Bushakra JM**, Bassil NV, Perkins-Veazie P, Dossett M, and **Finn CE**. Phenotypic evaluations of heat tolerance and fruit quality traits in segregating black raspberry (*Rubus occidentalis* L.) populations in North Carolina. Oral presentation. National Association of Plant Breeding, Minneapolis, MN, August, 2014.

Bradish C (presenter). Fernandez G, **Bushakra J**, Perkins-Veazie P, Dossett M, **Bassil N**, **Finn C**. Phenotypic evaluations of yield and fruit quality traits in segregating black raspberry (Rubus occidentalis L.) populations in North Carolina. Oral presentation. Southern Region – ASHS, Dallas, TX, February 2014.

Bryant D (co-presenter), **Bushakra JM** (co-presenter), Dossett M, Vining K, Filichkin S, Weiland JE, Lee J, Finn CE, Bassil NV, Mockler T. Oral presentation. Building the genomic infrastructure in black raspberry. ASHS, Orlando, FL. July 2014.

Bryant D (presenter), **Bushakra JM**, Vining K, Dossett M, **Finn CE**, Filichkin S, Weiland JE, **Bassil NV**, Mockler T. Poster & Oral presentation. Development of genomic resources in black raspberry. RGC7, Seattle, WA. June 2014.

Bushakra JM (presenter), Bradish CM, Weber CA, Scheerens JC, Dossett M, Peterson M, Fernandez G, **Lee J, Bassil NV, Finn CE**. Poster. Toward understanding genotype x environment interactions in black raspberry (*Rubus occidentalis* L.). ASHS, Orlando, FL. July

2014.

Bushakra JM (presenter), Bryant D, Bradish CM, Dossett M, Vining K, Weiland JE, Filichkin S, Perkins-Veazie P, Scheerens JC, Weber CA, Buck EB, Agunga R, Yang W, Fernández-Fernández F, Yun SJ, Lewers K, Graham J, Fernandez G, Mockler T, **Lee J, Finn CE, Bassil NV.** Oral presentation. Developing the genomic and genetic infrastructure for black raspberry. ASHS, Orlando, FL. July 2014.

Bushakra JM (presenter), Bryant D, Dossett M, Gilmore B, Filichkin S, Weiland JE, Peterson M, Bradish CM, Fernandez G, Lewers K, Graham J, **Lee J**, Mockler T, Bassil NV, **Finn CE**. Poster. Black raspberry genetic and genomic resource development. American Society of Plant Biologists, Portland, OR. July 2014.

Bushakra JM, Bryant D, Vining K, Dossett M, Mockler T, **Finn CE** (presenter), **Bassil NV.** Poster. Developing a genotype by sequencing protocol for linkage map construction in black raspberry (*Rubus occidentalis* L.). IHC, Brisbane, Australia. August 2014.

Bushakra JM, Bradish CM, Weber CA, Scheerens JC, Dossett M, Peterson M, Fernandez G, **Lee J, Bassil NV**, **Finn CE** (presenter). Oral presentation. Toward understanding genotype x environment interactions in black raspberry (*Rubus occidentalis* L.). IHC, Brisbane, Australia. August 2014.

Bushakra JM (presenter), Bryant D, Vining K, Dossett M, Mockler T, **Finn CE, Bassil NV**. Poster & Oral presentation. Linkage mapping of black raspberry. 7th Rosaceae Genome Conference (RGC7), Seattle, WA. June 2014.

Lee J (presenter), Dossett M, and **Finn CE.** Poster. Chemotaxonomy of black raspberry: issues with marketplace products. 2014 XXVIIth International Conference on Polyphenols (The 8th Tannin conference jointly hosted), Nagoya, Japan. September 2014.

Lee J (presenter), Dossett M, **Finn CE**. Poster. What's really in our black raspberry products?: chemotaxonomy by anthocyanin. Botany 2014-Botanical Society of America Conference, Boise, ID. July 2014.

Perkins-Veazie P (presenter)**,** Fernandez G, Bradish CM, Ma G, Scheerens JC, Weber CA, **Finn CE, Bassil NV, Bushakra JM**. Poster. Black raspberry fruit composition from seedling populations planted at multiple locations. ASHS, Orlando, FL. July 2014.

Application Cover Sheet

Application Date: November 11, 2010

Name of Applicant Organization/Company:
USDA-ARS, HCRL; 3420 NW Orchard Ave. Corvallis, OR 97330
USDA-ARS, NCGR; 33447 Peoria Rd., Corvallis, OR 97333

Principal Investigators:
Co-Project Directors
Chad Finn, USDA-ARS Research Geneticist
Nahla Bassil, USDA-ARS Research Geneticist
Jungmin Lee, USDA-ARS Research Chemist
Jill Bushakra, USDA-ARS Post Doc
Co PIs
Courtney Weber, Cornell Univ.
Gina Fernandez, NC State Univ.
Penny Perkins-Veazie, NC State Univ.
Joe Scheerens, Ohio State University
Emily Rhoades, Ohio State University
Robert Agunga, Ohio State University
Todd Mockler, Oregon State University
Other collaborators
Julie Graham, Scottish Crop Research Institute
Feli Fernandez-Fernandez, East Malling Research
Song Joong Yung, Chonbuk National University
Commercial growers

Project title:

Support of SCRI Proposal "Developing the Genomic Infrastructure for Breeding Improved Black Raspberries"

Year Initiated (current year) 2011 Current Year 2014 Terminating Year 2015

Funding
Total amount requested: $1,000/yr, $5,000 for 5 years

Our SCRI grant application was successful and we are receiving $1,590,717 to accomplish the goals set out in the proposal from 2011-2015. The grant was officially awarded October 1, 2011. The Washington Red Raspberry Commission had committed $1,000/year to this project if we were successful. We have also sought supporting funding from the North American Raspberry and Blackberry Association and the Oregon Raspberry and Blackberry Commission.

<u>Title of project:</u> Support of SCRI Proposal “Developing the Genomic Infrastructure for Breeding Improved Black Raspberries”

Year Initiated __2011_______ Current Year 2014_____ Terminating Year _2015__

<u>Brief description of project (<*200 words*) describing objectives and expected outcome.</u>

Specialty Crop Research Initiative Grants are a major source of funding for berry research. We recently received a $1.59 million dollar grant entitled "Developing the Genomic Infrastructure for Breeding Improved Black Raspberries".

This proposal seeks to advance and streamline efforts to identify a variety of traits of interest to growers and consumers in black raspberry germplasm, and then integrate them into breeding programs with the goal of developing new disease resistant cultivars that satisfy the demands of the marketplace while adding to the sustainability and profitability of the industry. A major focus of this project is to develop, and make available, genomic tools such as linkage maps, ESTs, SNP and SSR markers for use in raspberry breeding.

How does this tie into red raspberries in Washington? Black raspberries have historically been a source of valuable traits (e.g. disease and insect resistance, fruit firmness) in red raspberry. A great deal of what we learn will be applicable to red raspberry and the genomic information will be useful for the successful SCRI planning grant “Roadmap Development for U.S. Raspberry Producers: Forging Links Between New Tools for Breeding Programs and Crop Markets” and for the full project that we will submit next year.

<u>Justification and Background:</u> ***<u>(Issue you plan to address, why, 400 words maximum)</u>***

The Specialty Crop Research Initiative Grants have become a major source of funding for small fruit research. Last year we submitted a proposal called Developing the Genomic Infrastructure for Breeding Improved Black Raspberries that was successful. Within these grants we are expected to have a 50% match. We have significant commercial and academic matching funding but feel strongly that is important to ask for other funds that while only a small portion of the $1.74 million we have in matching shows an industries willingness to contribute. We asked for support last year and the WRRC said they would provide a $1000 match.

This proposal seeks to advance and streamline efforts to identify a variety of traits of interest to growers and consumers in black raspberry germplasm, and then integrate them into breeding programs with the goal of developing new disease resistant cultivars that satisfy the demands of the marketplace while adding to the sustainability and profitability of the industry. A major focus of this project is to develop, and make available, genomic tools such as linkage maps, ESTs, SNP and SSR markers for use in black and red raspberry breeding.

How does this tie into red raspberries in Washington? Black raspberries have historically been a source of valuable traits (e.g. disease and insect resistance, fruit firmness) in red raspberry breeding. We have characterized a great diversity of black raspberry germplasm and most importantly have identified 4 new sources of raspberry aphid resistance. If we can develop markers for traits such as these sources of aphid resistance, we can then fairly easily move them into red raspberry. We expect that a great deal of what we learn will be applicable to red raspberry and objective 5 clearly points to this. We also expect that the genomic information we learn will be useful for the project “Roadmap Development for U.S. Raspberry Producers: Forging Links Between New Tools for Breeding Programs and Crop Markets” that was successfully submitted as a planning grant and the full project that they will submit one year from now.

Relationship to WRRC Research priority(s):

Our objectives for raspberry breeding most closely align with a #1 Commission Priority as we are trying to develop cultivars “that are summer bearing high-yielding, winter hardy, machine harvestable, disease and virus resistant and have superior processed fruit quality. The traits we identify and the tools we develop will be useful in developing improved red raspberry cultivars.

Objectives:

The overall goal of this proposal is to develop and make available genomic tools for the improvement of black and red raspberry (*Rubus occidentalis,* and *R. idaeus,* respectively, subgenus *Idaeobatus*) and begin the application of these tools in using wild black raspberry germplasm for crop improvement. Specifically:

1) Transcriptome sequencing and high throughput genomic sequencing.
2) Developing molecular markers from genomic and EST sequences.
3) Studying genotype by environment interaction on specific traits of interest in crosses involving diverse wild black raspberry germplasm.
4) Using molecular markers for mapping specific traits of interest in crosses involving diverse wild black raspberry germplasm.
5) Evaluate transferability of SSR markers developed in black raspberry to red raspberry.
6) Better understanding of consumer preferences for market expansion.
7) Delivering research results and training in molecular breeding to the industry, breeders, and students through a multifaceted outreach program.

Procedures *(<400 words*):

I would be delighted to share the detailed procedures with the WRRC if they feel it would be useful. I sent a copy with this proposal to the WRRC office if someone is interested in reading the proposal.

Basically, we are growing out mapping populations from controlled crosses and they have been planted in multiple research and commercial settings. We will evaluate the plants for observable plant, fruit, and phenological traits and then tie this information to their genotype. In this process, we will develop markers for a wide variety of traits that will facilitate black and red raspberry breeding especially for traits that are not easily observable (e.g. aphid resistance) or so that you can stack more than once source of resistance into a genotype.

Anticipated Benefits and Information Transfer:

We will develop markers that will be useful in marker assisted red and black raspberry breeding. This will hopefully open up new opportunities and sources of variability for developing improved red and black raspberry cultivars.

Budget:

For each year 2011-2015

Salaries: Student labor (GS-2)	$1,000
Total per year	**$1,000**
Total for 2011-2015	**$5,000**

Project No:
Title: Cooperative raspberry cultivar development program

Personnel: Chad Finn, Research Geneticist
USDA-ARS, HCRL; 3420 NW Orchard Ave. Corvallis, OR 97330

Reporting Period: 2014

Accomplishments: Our goal is develop raspberry cultivars that either are improvements over the current standards or that will complement them. In addition, the information generated on advanced selections from the WSU and BC programs will be made available and aid in making decisions on the commercial suitability of their materials. 'Lewis', ORUS 1142-1, ORUS 3705-2, ORUS 3959-3 are in grower trials in Washington as floricane fruiters and the primocane fruiters ORUS 4090-1 and ORUS 4289-4 have been/are being propagated for trial. Three to five selections have been propagated for planting each year in machine harvest trials in Lynden/Mt. Vernon. We have 70 floricane fruiting and 35 primocane fruiting red raspberry selections from our crosses in trial, in addition to numerous WSU and BC selections (Table 1). ORUS 3239-1, ORUS 3696-1, ORUS 3700-2, and ORUS 3722-1 were identified as having excellent root rot resistance in Puyallup. Of these, ORUS 3722-1 has excellent commercial potential and is being propagated for Washington machine harvest trial; it also has an RBDV resistant parent. We made 32 red raspberry selections (20 floricane, 12 primocane).

Results: Thirty two crosses were made in spring 2014 and a new seedling field (~2500 seedlings) was established. We made 32 red raspberry selections (20 floricane, 12 primocane). The selections were mostly made as potential cultivars. We have been working with Asian germplasm for several generations and it is now nearly cultivar quality with some parental material displaying good root rot tolerance; ORUS 3229-1 is an example of this as it has vigor on heavy soils, high yields, easy to harvest… but is yellow and a bit rough. We hope this material will be useful to our program as well as to Pat Moore's and Michael Dossett's. Table RY1 lists the genotypes that were harvested in 2014 or will be harvested in 2015. Presented in Tables RY2-RY8 are the results from 2014. ORUS 3705-2 and ORUS 4090-1 have been propagated for grower trial in addition to ORUS 1142-1 and 'Lewis'. ORUS 3696-1 and ORUS 3722-1 were identified as having excellent root rot resistance in Puyallup. ORUS 3696-1 has excellent potential as a parent, while ORUS 3722-1 has good commercial potential and is being propagated for Washington machine harvest trial; it also has an RBDV resistant parent.

While indirectly related to red raspberry, our efforts in black raspberry have identified verticillium wilt and aphid resistance (that should translate into virus resistance for the aphid transmitted viruses). If these sources of resistance hold up, they can be moved into red raspberry especially if there are molecular markers to identify genotypes with resistance.

Publications:

Moore, P.P, B. Barritt, T. Sjulin, J.A. Robbins, C.E. Finn, R.R. Martin, and M. Dossett. 2014. 'Cascade Gold' raspberry. HortScience 49:358-360.

Finn, C.E. 2014. United States Plant Patent: Red Raspberry plant named 'Vintage' PP24,198. Washington, DC.

Finn, C.E., B.C. Strik, B.M. Yorgey, and R.R. Martin. 2013. 'Vintage' red raspberry. HortScience 48:1181-1183.

Appendices

Table RY1. Red raspberry genotypes in trial at OSU-NWREC in 2014; 299 plots evaluated

Floricane Fruiters				*Primocane Fruiters*	
ORUS 1025-10	ORUS 4089-2	WSU 1447	BC 1-16-38	ORUS 3983-3	ORUS 4386-1
ORUS 1040-1	ORUS 4094-1	WSU 1499	BC 3-14-12	ORUS 4086-1	ORUS 4388-1
ORUS 3229-1	ORUS 4095-1	WSU 1511	BC 93-6-30	ORUS 4086-2	ORUS 4388-2
ORUS 3234-1	ORUS 4178-1	WSU 1539	BC 96-22R-55	ORUS 4086-3	ORUS 4388-3
ORUS 3519-1	ORUS 4179-1	WSU 1660	BC 97-30-20	ORUS 4090-2	ORUS 4389-1
ORUS 3523-1	ORUS 4283-1	WSU 1738		ORUS 4097-1	ORUS 4486-1
ORUS 3525-1	ORUS 4283-2	WSU 1750		ORUS 4097-3	ORUS 4487-1
ORUS 3528-1	ORUS 4283-3	WSU 1792	Cascade Bounty	ORUS 4097-4	ORUS 4487-2
ORUS 3533-1	ORUS 4284-1	WSU 1794	Cascade Delight	ORUS 4097-5	ORUS 4487-3
ORUS 3533-2	ORUS 4284-2	WSU 1912	Cascade Harvest	ORUS 4098-1	ORUS 4494-1
ORUS 3534-1	ORUS 4284-3	WSU 1914	Chemainus	ORUS 4099-2	ORUS 4494-2
ORUS 3702-3	ORUS 4371-1	WSU 1948	Lewis	ORUS 4280-1	ORUS 4495-1
ORUS 3705-2	ORUS 4371-2	WSU 1964	Meeker	ORUS 4280-2	
ORUS 3718-1	ORUS 4371-3	WSU 1996	Oregon 1030	ORUS 4280-3	NY 02-57
ORUS 3722-1	ORUS 4371-4	WSU 2010	Royalty	ORUS 4285-1	NY 05-44
ORUS 3767-1	ORUS 4371-5	WSU 2011	Rudi	ORUS 4287-1	
ORUS 3958-1	ORUS 4373-1	WSU 2029	Saanich	ORUS 4289-1	Anne
ORUS 3959-2	ORUS 4375-1	WSU 2068	Squamish	ORUS 4289-2	Crimson Giant
ORUS 3959-3	ORUS 4380-1	WSU 2075	TulaMagic (Frutafri)	ORUS 4289-3	Crimson Night
ORUS 4075-1	ORUS 4380-2		Tulameen	ORUS 4289-4	Double Gold
ORUS 4076-1	ORUS 4380-3		Ukee	ORUS 4289-5	Heritage
ORUS 4080-1	ORUS 4380-4		Wakefield	ORUS 4291-1	TulaMagic (Frutafri)
ORUS 4089-1	ORUS 4465-1			ORUS 4384-1	Vintage

Table RY2. Mean yield and berry size in 2013-14 for floricane fruiting raspberry genotypes at OSU-NWREC planted in 2011.

	Berry size (g)	Yield (tons·a^{-1})		
Genotype	2013-14[z]	2013	2014	2013-14
2013	3.85 a			5.66 a
2014	3.63 a			2.99 a
Replicated				
WSU 1660	3.3 d	4.24 a	4.20 a	4.22 a
WSU 1792	5.2 a	3.16 b	4.13 ab	3.65 ab
Meeker	**3.3 cd**	**3.38 ab**	**3.34 a-d**	**3.36 bc**
WSU 1750	3.4 cd	2.92 b	3.73 a-c	3.33 bc
WSU 1948	3.5 cd	2.74 bc	3.00 b-e	2.87 c
Ukee	**3.6 c**	**2.89 b**	**2.72 c-e**	**2.81 c**
ORUS 3959-3	4.8 b	3.08 b	2.51 de	2.79 c
WSU 1912	2.9 e	1.86 c	2.09 e	1.97 d
	-			-
Nonreplicated				
ORUS 4179-1 (purple)	2.9	3.21	2.22	2.72

[z] Mean separation within columns by LSD, p≤0.05.

Table RY3. Mean yield and berry size in 2014 for floricane fruiting red raspberry genotypes in replicated and observation trials at OSU-NWREC planted in 2012.

Genotype	Berry size (g)[z]	Yield (tons·a^{-1})
Replicated		
Lewis	**4.6 a**	**5.11 a**
Squamish	**3.8 b**	**3.90 b**
ORUS 3705-2	4.0 b	3.55 b
ORUS 4284-1	3.2 cd	3.41 b
Meeker	**3.1 cd**	**3.34 b**
WSU 2011	2.9 d	3.23 bc
WSU 1964	3.1 d	2.94 bc
ORUS 4283-1	3.6 bc	2.28 c
Nonreplicated		
ORUS 4283-2	3.8	4.01
WSU 1499	2.6	3.64
ORUS 4089-2	3.5	3.59
ORUS 4284-2	4.4	2.93
ORUS 4089-1	3.6	2.57
ORUS 4284-3	3.2	2.29
Royalty (purple)	4.2	1.84

[z] Mean separation within columns by LSD, p≤0.05.

Table RY4. Mean yield and berry size in 2012-2014 for primocane fruiting raspberry genotypes at OSU-NWREC planted in 2011.

	Berry size (g)	Yield (tons·acre^{-1})			
	2012-14	2012	2013	2014	2012-14
2012	3.5 a				2.08 a
2013	3.5 a				2.19 a
2014	2.6 a				1.69 a
Replicated					
ORUS 4097-1	3.7 a	2.12 a	2.26 a	1.80 a	2.06 a
ORUS 4097-5	2.7 b	2.05 a	2.13 a	1.58 a	1.92 a
Non replicated					
ORUS 4280-1	3.6	2.40	2.04	1.20	1.88
ORUS 4289-1	2.2	1.35	1.26	1.11	1.24
Vintage	**2.9**		**1.34**	**1.10**	**1.22**

Mean separation within columns by LSD, $p \leq 0.05$.

Table RY5. Mean yield and berry size in 2013-14 for primocane fruiting red raspberry genotypes at OSU-NWREC planted in 2012.

	Berry size (g)		Yield ($tons \cdot a^{-1}$)		
	2013-14		2013	2014	2014-14
2013	3.0	a			1.74 a
2014	2.4	a			1.86 a
Replicated					
ORUS 4289-4	2.2	b	2.20 a	2.41 a	2.31 a
Crimson Giant	**4.5**	**a**	**2.03 a**	**2.25 a**	**2.14 a**
Heritage	**2.2**	**b**	**2.11 a**	**2.11 a**	**2.11 a**
ORUS 4289-1	2.2	b	1.29 a	1.28 b	1.29 b
ORUS 4289-3	2.2	b	1.35 a	1.26 b	1.30 b
ORUS 4291-1			-	1.23 b	
Non replicated					
NY 02-57	2.5		1.96	2.95	2.45
ORUS 4289-5	2.1		2.28	2.24	2.26
Crimson Night	**2.7**		**2.01**	**1.25**	**1.63**
NY 05-44	2.4		0.96	1.45	1.21
Niwot (black rasp)	**2.3**		**0.46**	**1.05**	**0.75**
Double Gold	**2.4**		**0.65**	**0.29**	**0.47**

Mean separation within columns by LSD, $p \leq 0.05$.

Table RY6. Mean yield and berry size in 2014 for primocane fruiting red raspberry genotypes at OSU-NWREC planted in 2013.

Genotype	Berry size (g)		Yield ($tons \cdot a^{-1}$)	
Replicated				
ORUS 4487-1	2.2	b	2.88	a
ORUS 4494-2	2.7	a	2.22	b
Heritage	**1.7**	**c**	**2.03**	**b**
ORUS 4086-2	2.7	a	1.66	c
Vintage	**2.6**	**a**	**1.13**	**d**
ORUS 4090-2	2.5	a	0.77	e
Non replicated				
ORUS 4494-1	3.3		3.55	
ORUS 4486-1	1.8		3.01	
ORUS 4487-2	2.2		2.55	
ORUS 4487-3	2.2		2.16	
ORUS 4388-3	2.9		2.14	
ORUS 4388-2	2.8		1.67	
ORUS 4384-1	2.4		1.58	
TulaMagic	**3.1**		**1.49**	

Mean separation within columns by LSD, $p \leq 0.05$.

Table RY7. Ripening season for floricane fruiting red raspberry genotypes at OSU-NWREC. Planted in 2010-11 and harvested 2012-13.

Genotype	Year planted	Harvest season 5%	50%	95%	No. years in mean	Rep/ Obsv
ORUS 4284-2	2012	10-Jun	17-Jun	1-Jul	1	Obsv.
Squamish	**2012**	**10-Jun**	**17-Jun**	**1-Jul**	**1**	**Rep**
ORUS 4089-1	2012	10-Jun	24-Jun	8-Jul	1	Obsv.
ORUS 4283-2	2012	10-Jun	24-Jun	8-Jul	1	Obsv.
ORUS 4179-1	2011	14-Jun	24-Jun	5-Jul	2	Obsv.
ORUS 4283-1	2012	17-Jun	1-Jul	8-Jul	1	Rep
WSU 1499	2012	17-Jun	1-Jul	8-Jul	1	Obsv.
ORUS 4284-3	2012	17-Jun	1-Jul	13-Jul	1	Obsv.
Meeker	**2012**	**17-Jun**	**1-Jul**	**15-Jul**	**1**	**Rep**
ORUS 4089-2	2012	17-Jun	1-Jul	15-Jul	1	Obsv.
WSU 1964	2012	17-Jun	1-Jul	15-Jul	1	Rep
Lewis	**2012**	**17-Jun**	**1-Jul**	**22-Jul**	**1**	**Rep**
WSU 2011	2012	17-Jun	1-Jul	22-Jul	1	Rep
ORUS 4284-1	2012	24-Jun	1-Jul	15-Jul	1	Rep
WSU 1660	2011	17-Jun	1-Jul	15-Jul	2	Rep
Meeker	**2011**	**21-Jun**	**5-Jul**	**15-Jul**	**2**	**Rep**
WSU 1948	2011	21-Jun	5-Jul	24-Jul	2	Rep
Ukee	**2011**	**24-Jun**	**5-Jul**	**22-Jul**	**2**	**Rep**
Royalty (purple)	**2012**	**24-Jun**	**8-Jul**	**8-Jul**	**1**	**Obsv**.
ORUS 3705-2	2012	24-Jun	8-Jul	22-Jul	1	Rep
WSU 1750	2011	24-Jun	8-Jul	22-Jul	2	Rep
WSU 1792	2011	28-Jun	8-Jul	22-Jul	2	Rep
ORUS 3959-3	2011	5-Jul	15-Jul	26-Jul	2	Rep

Table RY8. Ripening season for primocane fruiting red raspberry genotypes at OSU-NWREC. Planted in 2010-12 and harvested 2011-13.

Genotype	Year planted	Harvest season 5%	50%	95%	No. years in mean	Rep/ Obsv
ORUS 4280-1	2011	30-Jul	8-Aug	22-Aug	3	Obsv.
Vintage	**2011**	**2-Aug**	**9-Aug**	**26-Aug**	**2**	**Obsv.**
ORUS 4487-1	2013	30-Jul	12-Aug	2-Sep	1	Rep
ORUS 4090-2	2013	5-Aug	12-Aug	2-Sep	1	Rep
ORUS 4487-2	2013	5-Aug	12-Aug	2-Sep	1	Obsv.
ORUS 4494-1	2013	5-Aug	12-Aug	2-Sep	1	Obsv.
NY 05-44	2012	5-Aug	16-Aug	26-Aug	2	Obsv.
NY 02-57	2012	5-Aug	16-Aug	2-Sep	2	Obsv.
ORUS 4289-4	2012	9-Aug	16-Aug	30-Aug	2	Rep
ORUS 4289-5	2012	12-Aug	16-Aug	2-Sep	2	Obsv.
ORUS 4384-1	2013	5-Aug	19-Aug	2-Sep	1	Obsv.
ORUS 4494-2	2013	5-Aug	19-Aug	2-Sep	1	Rep
Vintage	**2013**	**5-Aug**	**19-Aug**	**2-Sep**	**1**	**Rep**
ORUS 4388-2	2013	12-Aug	19-Aug	2-Sep	1	Obsv.
ORUS 4289-3	2012	9-Aug	19-Aug	30-Aug	2	Rep
Heritage	**2012**	**9-Aug**	**19-Aug**	**6-Sep**	**2**	**Rep**
ORUS 4289-1	2012	12-Aug	19-Aug	2-Sep	2	Rep
ORUS 4097-3	2011	15-Aug	24-Aug	12-Sep	3	Obsv.
Heritage	**2013**	**12-Aug**	**26-Aug**	**9-Sep**	**1**	**Rep**
ORUS 4486-1	2013	19-Aug	26-Aug	9-Sep	1	Obsv.
ORUS 4487-3	2013	19-Aug	26-Aug	9-Sep	1	Obsv.
Crimson Night	**2012**	**16-Aug**	**26-Aug**	**13-Sep**	**2**	**Obsv.**
Niwot (black rasp)	**2012**	**16-Aug**	**26-Aug**	**16-Sep**	**2**	**Obsv.**
ORUS 4097-1	2011	10-Aug	27-Aug	21-Sep	3	Rep
ORUS 4289-1	2011	18-Aug	27-Aug	10-Sep	3	Obsv.
ORUS 4086-2	2013	12-Aug	2-Sep	16-Sep	1	Rep
TulaMagic (Frutafri)	**2013**	**19-Aug**	**2-Sep**	**9-Sep**	**1**	**Obsv**.
ORUS 4388-3	2013	26-Aug	2-Sep	9-Sep	1	Obsv.
Crimson Giant	**2012**	**12-Aug**	**2-Sep**	**20-Sep**	**2**	**Rep**
Double Gold	**2012**	**26-Aug**	**2-Sep**	**13-Sep**	**2**	**Obsv.**
ORUS 4097-5	2011	13-Aug	3-Sep	26-Sep	3	Rep

Project Title: Cooperative raspberry cultivar development program

PI: Chad Finn,
USDA-ARS, HCRL
Research Geneticist
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Cooperators: Pat Moore, WSU
Michael Dossett Agriculture and Agri-Foods Canada

Year Initiated __2013___ **Current Year** 2015-2016__ **Terminating Year** _Continuing__

Total **Project Request:** Ongoing.

Other funding sources:

Current pending and support form attached

I receive and apply for funding each year with Bernadine Strik from the Oregon Raspberry and Blackberry Commission towards the cooperative raspberry and blackberry breeding program. This funding is complementary not duplicative.

Description describing objectives and specific outcomes

The Northwest is one of the most important berry production regions in the world. This success is due to a combination of an outstanding location, top notch growers, and a strong history of industry driven research. The USDA-ARS berry breeding programs in Corvallis have a long history of developing cultivars that are commercially viable. New cultivars that are high yielding, machine harvestable, and that produce very high quality fruit are essential for the long term viability of the industry. Cultivars that replace or complement the current standards, primarily 'Meeker' or 'Wakefield' would help towards that goal. The breeding programs in the region have a long history of cooperation exchanging parents, seedlings, and ideas and thoroughly testing and evaluating each other's selections. Cultivars developed by these integrated programs will benefit the entire industry in the northwest. The specific objectives include developing:

- Cultivars for the Pacific Northwest in cooperation with Agriculture and Agri-Food Canada and Washington State University that are summer bearing high-yielding, winter hardy, machine harvestable, disease and virus resistant and have superior processed fruit quality (#1 Priority).
- Fresh market cultivars will be pursued that provide season extension: improve viability of fresh marketing through floricane or primocane fruiting types (Of Note Priority).

Relationship to WRRC Research Priorities.

The objectives tie directly to the following priorities:

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

Ideally new cultivars will have improved pest resistance and so this work ties indirectly to the following priorities:

- Fruit rot including pre harvest, postharvest, and/or shelf life.
- Viruses/crumbly fruit
- Foliar & Cane Diseases – i.e. spur blight, yellow rust, cane blight, etc.

Objectives:

- To develop cultivars for the Pacific Northwest in cooperation with Agriculture and Agri-Food Canada and Washington State University that are summer bearing high-yielding, winter hardy, machine harvestable, disease and virus resistant and have superior processed fruit quality (#1 Commission Research Priority).
- New fresh market cultivars will be pursued that provide season extension: improve viability of fresh marketing through floricane or primocane fruiting types (Of Note Priority).
- To develop cultivars using new germplasm that are more vigorous and that may be grown using reduced applications of nutrients and irrigation (#2 Priority) and that are less reliant on soil fumigation (#1 Priority).

Procedures:

This is an ongoing project where cultivars and current selections serve as the basis for generating new populations from which new selections can be made, tested, and either released as a new cultivar or serve as a parent for further generations. All of the steps are taking place every year i.e. crossing, growing seedlings, selecting, propagating for testing, and testing.

Thirty to forty crosses will be done each year. Seedling populations are grown and evaluated in Corvallis, Ore. Selections are made and propagated for testing at the Oregon State University - North Willamette Research and Extension Center (Aurora, Ore.). Washington State University and Agriculture and Agri-Food Canada selections, in addition to the USDA-ARS selections, that looked outstanding as a seedling or that have performed well in other trials, are planted in replicated trials (4, 3 plant replications). Selections that we are less sure of are generally planted in smaller observation trials (single, 3 plant plot). Fruit from replicated and observation plots are harvested and weighed, and plants and fruit are subjectively evaluated as well for vigor, disease tolerance, winter hardiness, spines, ease of removal, color, firmness, and flavor.

Fruit from the best selections are processed after harvest for evaluation in the off season.

Selections that look promising are propagated for grower trials, machine harvest trials, and for evaluation trials at other locations in Washington and B.C. This usually involves cleaning up the selections in tissue culture and then working with nurseries to generate plants for trials.

While not directly related to red raspberry at first glance, our efforts in black raspberry, which are supported by separate funding, have the potential to positively impact red raspberry. While much is specific to black raspberry, our work on aphid resistance should have applications for red raspberry. We have screened populations from across the eastern US for resistance to raspberry aphid, which is a major vector for several viruses. To this point we have identified three sources of resistance and are in the process of studying these sources further and of developing molecular markers that can be used to more efficiently select for this trait in the breeding program. We have also identified sources of verticillium resistance in this material while 'Meeker' was susceptible. These sources can be moved into red raspberry relatively easily if there are molecular markers to facilitate identifying genotypes with resistance.

Anticipated Benefits and Information Transfer:

This breeding program will develop new raspberry cultivars that either are improvements over the current standards or that will complement current standards. In addition, the information generated on advanced selections from the WSU and B.C. programs will be made available and aid in making decisions on the commercial suitability of their materials.

Results of all trials will be made available to the industry to help them make decisions in their operations.

Budget:

Amount allocated by Commission for previous year: $__4,000______

Funds from the USDA-ARS will be used to provide technician support and the bulk of the funding of the overall breeding project.

Salaries: Student labor (GS-2)	$3,500
Operations (goods & services)	500
Travel[1]	1,000
Other: "Land use charge" ($3,500/acre)	2,000
Total	**$7,000**

[1]To visit Puyallup, Lynden, and/or grower trials and field days in Washington

Current & Pending Support					
Chad Finn					
Name(List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
Current:					
Finn, C.E.	North American Raspberry and Blackberry Assoc.	$3,000	7/2014-6/2015	1	Funds towards industry matching on SCRI grant "Developing the Genomic Infrastructure for Breeding Improved Black Raspberries"
Finn, C.E.	Oregon Raspberry and Blackberry Commission	$1,000	7/2014-6/2015	1	Funds towards industry matching on SCRI grant "Developing the Genomic Infrastructure for Breeding Improved Black Raspberries"
Finn, C.E.	Oregon Blueberry Commission	$13,068	7/2014-6/2015	2	Developing PNW Cultivars That May Resist Blueberry Shock Virus
Strik, BC, and Finn, C.E.	Oregon Blueberry Commission	$17,000	7/2014-6/2015	2	Cooperative Breeding Program- Blueberries
Strik, B.C. and C.E. Finn	Oregon Raspberry and Blackberry Commission	$24,280	7/2014-6/2015	2	Production System/Physiology Research and Cooperative Breeding Program- Raspberries and Blackberries
Strik, B.C. and C.E. Finn	Oregon Strawberry Commission	$12,750	7/2014-6/2015	2	Cooperative Breeding Program - Strawberries
Finn, C.E., N.V. Bassil, J. Lee, G. Fernandez, P. Perkins-Veazie, C. Weber, T. Mockler, R. Agunga, E. Rhoades, J.C. Scheerens, W. Yang, K. Lewers, J. Graham, F. Fernández Fernández, S.J.. Yun.	USDA Specialty Crop Research Initiative	$1,590,717	10/1/2011-9/30/2015	10	Developing the Genomic Infrastructure for Breeding Improved Black Raspberries
Finn, C.E.	Washington Blueberry Commission	$6,000	7/2014-6/2015	2	Blueberry breeding-Cultivar and Selection evaluation

Finn, C.E.	Washington Strawberry Commission	$2,500	7/2014-6/2015	2	USDA-ARS Cooperative Strawberry Breeding Program
Finn, C.E.	Washington Red Raspberry Commission	$5,000	7/2014-6/2015	2	Cooperative raspberry cultivar development program.
Finn, C.E.	Washington Red Raspberry Commission	$1,000	7/2014-6/2015	1	Funds towards industry matching on SCRI grant "Developing the Genomic Infrastructure for Breeding Improved Black Raspberries"
Finn, C.E.	Oregon Blueberry Commission	$13,068	7/2014-6/2015	2	Developing PNW Cultivars That May Resist Blueberry Shock Virus
Strik, BC, and Finn, C.E.	Oregon Blueberry Commission	$18,000	7/2014-6/2015	2	Cooperative Breeding Program- Blueberries
Finn, C.E.	Washington Blueberry Commission	$6,000	7/2014-6/2015	2	Developing PNW Cultivars That May Resist Blueberry Shock Virus
Iezzoni, A., C. Peace, K. Gasic, J. Luby, C. Finn, J. Norelli, D. Main and 27 others (including P. Moore)	USDA Specialty Crop Research Initiative	$10 million total; $1.8 million annual; $15K to USDA Breeding	10/2014-9/2019	5	RosBREED: Combining Disease Resistance With Horticultural Quality In New Rosaceous Cultivars
Name(List PI #1 first)					
Pending:					
Finn, C.E.	Washington Strawberry Commission	$7,725	7/2015-6/2016	2	USDA-ARS Cooperative Strawberry Breeding Program
Finn, C.E.	Washington Red Raspberry Commission	$7,000	7/2015-6/2016	2	Cooperative raspberry cultivar development program.
Finn, C.E.	Washington Red Raspberry Commission	$1,000	7/2015-6/2016	1	Funds towards industry matching on SCRI grant "Developing the Genomic Infrastructure for Breeding Improved Black Raspberries"
Finn, C.E.	Oregon Raspberry and Blackberry Commission	$1,000	7/2015-6/2016	1	Funds towards industry matching on SCRI grant "Developing the Genomic Infrastructure for Breeding Improved Black Raspberries"

Strik, B.C. and C.E. Finn	Oregon Raspberry and Blackberry Commission	$24,280	7/2015-6/2016	2	Production System/Physiology Research and Cooperative Breeding Program- Raspberries and Blackberries
Strik, B.C. and C.E. Finn	Oregon Strawberry Commission	$12,750	7/2015-6/2016	2	Cooperative Breeding Program - Strawberries

Project: 13C-3755-5641
Title: Red Raspberry Breeding, Genetics and Clone Evaluation
Personnel: Patrick P. Moore, Scientist, Washington State University Puyallup Research and Extension Center
Wendy Hoashi-Erhardt, Scientific Assistant, WSU Puyallup
Reporting Period: 2014
Accomplishments:
Advanced Selections:
Three WSU selections (WSU 1507, WSU 1912 and WSU 1948) were included in the 2012 grower trial plantings. WSU 1507 was released in late 2013 as 'Cascade Harvest'. These selections were harvested at all test sites in 2014. Four WSU selections, (WSU 1980, WSU 2122, WSU 2166 and WSU 2188) were planted in the 2014 grower trial plantings.

Crosses/seedlings/selections. Sixty-four crosses were made in 2014 with emphasis on machine harvestability. All of the crosses had at least one selection that had been evaluated in machine harvesting trials and most had both parents that had been evaluated in machine harvesting trials. These seeds will be germinated in the greenhouse, planted in the field in 2015 and selections made in 2017. Seventy-three selections were made in 2014 with 50 having one RBDV resistant parent and 11 having both parents RBDV resistant. Thirty-three of the selections had 'Cascade Harvest' as one of the parents.

Machine Harvesting Trials. A new machine harvesting trial was planted in Lynden with 40 WSU selections, 47 BC selections, 6 ORUS selections and 'Cascade Harvest', 'Meeker' and 'Willamette' for reference. This planting will be harvested in 2016 and 2017. The most promising of the selections planted in the 2011 and 2012 machine harvesting trials will be planted with a cooperating grower for additional evaluation.

Selection Trial Puyallup. The 2011 and 2012 replicated plantings at Puyallup were hand harvested in 2014. In the 2012 planting, there were four WSU selections that had yields over 10 t/a (Table 1). WSU 1980 had much firmer fruit than any of the other material in this planting and was the latest ripening. 'Squamish' had a midpoint of harvest that was three days earlier than 'Willamette', but in this planting had low yields. In the 2011 planting, 'Cascade Bounty', 'Meeker', 'Rudi' and WSU 1738 had the highest two-year yields (Table 2). 'Rudi' had a midpoint of harvest two days earlier than 'Willamette'. WSU 1738, WSU 1948 and WSU 1912 had the latest midpoint of harvest.

Publications:
Machine Harvesting Open House. Lynden, WA. July 17, 2014.

Moore, P.P., W. Hoashi-Erhardt, B.H. Barritt, T.M. Sjulin, J.A. Robbins, C.E. Finn, R.R. Martin and M. Dossett. 2014. 'Cascade Gold' Raspberry. HortScience 49:358-360.

Chad E. Finn, Bernadine C. Strik and Patrick P. Moore. 2014. Raspberry Cultivars for the Pacific Northwest (PNW 655) https://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/45870/pnw655.pdf

Table 1. 2014 harvest of 2012 planted raspberries at Puyallup, WA.

	Yield (t/a)		Fruit weight (g)		Fruit rot (%)		Fruit firmness (g)		Midpoint of harvest	
WSU 2011	11.7	a	3.05	c	1.8%	a	79	d	7/5	b-d
WSU 1956	11.6	a	3.78	ab	4.1%	a	119	bc	7/10	ab
WSU 1980	10.3	a	3.83	ab	2.7%	a	171	a	7/13	a
WSU 1984	10.3	a	3.82	ab	3.0%	a	136	b	7/6	b-d
Willamette	9.9	a	3.47	bc	2.7%	a	96	cd	6/26	e
WSU 1964	9.5	a	3.34	bc	2.7%	a	86	d	7/1	d
WSU 1977	8.5	a	4.30	a	3.8%	a	109	b-d	7/7	bc
Meeker	7.7	a	3.33	bc	3.5%	a	110	b-d	7/5	cd
Squamish	5.4	a	3.69	ab	4.7%	a	107	b-d	6/23	e
	9.4		3.6		3.2%		112		7/4	

Table 2. 2013-2014 yield of 2011 planted raspberries, Puyallup, WA

	Yield (t/a)			Fruit weight (g)		Fruit rot (%)		Fruit firmness (g)		Midpoint of harvest	
	2014	2013	Total	2014	2013	2014	2013	2014	2013	2014	2013
C Bounty	13.0 a	8.7 a-c	21.7 a	4.2 b	3.5 bc	5.1% a	7.1% a-c	95 d	149 b	7/8 c	7/10 cd
Meeker	10.0 ab	10.5 a	20.5 a	3.9 b-d	3.6 bc	4.1% a	4.9% a-c	134 a-c	159 ab	7/9 bc	7/12 b-d
Rudi	10.3 ab	10.0 ab	20.3 a	4.2 b	4.0 ab	3.6% a	9.0% a	135 ab	160 ab	6/28 d	6/29 f
WSU 1738	10.3 ab	8.2 a-c	18.5 ab	4.2 bc	3.5 bc	7.6% a	6.9% a-c	124 a-d	160 ab	7/14 a	7/15 a
WSU 1948	7.7 bc	8.7 a-c	16.4 a-c	3.1 e	3.2 c	5.9% a	3.9% bc	100 cd	156 ab	7/14 a	7/14 ab
WSU 1912	6.9 bc	7.4 bc	14.3 b-d	3.6 d	3.0 c	3.1% a	3.6% bc	125 a-d	162 ab	7/12 ab	7/11 cd
BC96-22R-55	5.4 bc	6.5 c	11.9 cd	5.3 a	4.2 a	5.1% a	3.3% c	144 a	167 a	7/8 c	7/13 a-c
Willamette	4.3 c	6.5 c	10.8 d	3.7 cd	3.6 bc	6.2% a	8.1% ab	105 b-d	152 ab	6/30 d	7/2 e
	8.5	8.3	16.8	4.0	3.6	5.1%	5.9%	120	158	7/8	7/9

PROJECT: 13C-3755-5641
TITLE: Red Raspberry Breeding, Genetics and Clone Evaluation
CURRENT YEAR: 2014

PI:	Patrick P. Moore, Professor 253-445-4525 moorepp@wsu.edu WSU Puyallup Research and Extension Center 2606 W Pioneer Puyallup, WA 98372	**Co-PI:** Wendy Hoashi-Erhardt, Scientific Assistant 253-445-4641 wkhe@wsu.edu

Year initiated 1987 **Current year 2015** **Proposed Duration:** continuing
Project Request: $75,000 for 2015-2016

Other funding sources: USDA/ARS Northwest Center for Small Fruits Research
$32,419 for 2014-2015 for both raspberry and strawberry breeding

Description: The program will develop new red raspberry cultivars for use by commercial growers in Washington. Using traditional breeding methods, the program will produce seedling populations, make selections from the populations and evaluate the selections. Selections will be evaluated for adaptation to machine harvestability by planting selections with cooperating growers. Promising selections will be propagated for grower trials and superior selections will be released as new cultivars. Specific traits to incorporate into new cultivars are high yield, machine harvestability, raspberry bushy dwarf virus (RBDV) resistance and root rot tolerance with superior processed fruit quality.

Justification and Background: The Pacific Northwest (PNW) breeding programs have been important in developing cultivars that are the basis for the industry in the PNW. New cultivars are needed that are more productive, machine harvestable, RBDV resistant and tolerant to root rot while maintaining fruit quality. Replacement cultivars for 'Willamette' and 'Meeker' and new cultivars that extend the season are needed. With 99+% of the Washington production used for processing, new cultivars need to be machine harvestable.

There has been a history of cooperation between the breeding programs in Oregon, British Columbia, and Washington and material from other programs evaluated. This cooperation needs to continue as cultivars developed by these programs will be of value to the entire PNW raspberry industry.

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: Develop summer fruiting red raspberry cultivars with improved yields and fruit quality, and resistance to root rot and raspberry bushy dwarf virus. Selections adapted to machine harvesting or fresh marketing will be identified and tested further.

Procedures: This is an ongoing project that depends on continuity of effort. New crosses will be made each year, new seedling plantings established, new selections made among previously established seedling plantings, and selections made in previous years evaluated.

1. Crosses will be made for summer fruiting cultivar development. Primary criteria for selecting parents will be machine harvestability, RBDV resistance, root rot tolerance, yield and flavor.

2. Seed from the crosses made in 2014 will be sown in 2014-2015. The goal will be to plant 108 plants for each cross.

3. Selections will be made among the seedlings planted in 2013. Seedlings will be subjectively evaluated for yield, flavor, color, ease of harvest, freedom from pests, appearance, harvest season and growth form. Based on these observations, seedlings will be selected for propagation and further evaluation. Typically, the best 1% or less of a seedling population will be selected.

4. The selected seedlings will be propagated for testing. Shoots will be collected and placed into tissue culture. Selections that are not successfully established in tissue culture will be propagated by root cuttings, grown in the greenhouse and then propagated by tissue culture.

5. Eight plants of each selection will be planted in a grower planting for machine harvesting evaluation. Three plants of each selection will also be planted at WSU Puyallup in observation plots.

6. The machine harvesting trials established in 2012 and 2013 will be harvested in 2015. Evaluations will be made multiple times through the harvest season.

7. Samples of fruit from promising selections will be collected and analyzed for soluble sugars, pH, titratable acidity and anthocyanin content.

8. Selections that appear to machine harvest well will be planted in a second machine harvesting trial, in replicated plantings at WSU Puyallup for collection of hand harvest data and screened for root rot tolerance and RBDV resistance (if potentially resistant based on parentage).

9. The replicated plantings established in 2012 and 2013 at WSU Puyallup will be hand harvested for yield, fruit weight, fruit rot and fruit firmness.

10. Selections identified in machine harvest trials and other evaluations as having potential for release as a new cultivar will be propagated for grower trials in plantings sufficient to evaluate for suitability for IQF use.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:
This program will develop new raspberry cultivars that are more productive or more pest resistant. The emphasis of the program is on developing machine harvestable cultivars. Such cultivars may result from crosses made this year or may already be under evaluation. When a superior selection is identified and adequately tested, it may be released as a new cultivar and be available for commercial plantings. Promising selections and new cultivars will be displayed at field days. Presentations will be made on breeding program activities at grower meetings.

PROPOSED BUDGET:
Funds from the Northwest Center for Small Fruit Research and support provided by WSU Agriculture Research Center will be used to provide partial technical support for the program.

The funds requested will be used for technical support, timeslip labor; field, greenhouse, and laboratory supplies; and travel to research plots and to grower meetings to present results of research. The proposed budget also includes $3,000 for farm service fees and $5,000 for equipment use fees

Budget:	**2015-2016**
00 Salaries	$12,290
Scientific Assistant (0.10 FTE)	
Ag Res Tech 2 (0.10 FTE)	
Ag Res Tech 1 (0.10 FTE)	
01 Timeslip Labor	26,000
03 Service and Supplies	24,132[1]
04 Travel	4,000[2]
07 Benefits	
SA, ART2, ART1	6,030
Timeslip	2,548
Total	**$75,000**

[1] Includes: Field, greenhouse, and laboratory supplies; $3,000 for farm service fees, $5,000 for equipment use fees and $13,000 for expenses for the following test plantings for evaluation of raspberry selections.

Maintenance and harvest of test plantings
Machine harvesting trial established in 2012 – Honcoop Farms $3,000
Machine harvesting trial established in 2013– Curt Maberry Farms $3,000

Maintenance of test plantings
Machine harvesting trial established in 2014 – Maberry Packing $3,000

Establishment and maintenance of new test planting
Machine harvesting trial to be established in 2015
Will work with the WRRC to identify a suitable grower for the 2015 machine harvesting trial $4,000

[2] Travel to research plots and to grower meetings to present results of research

Current Support

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	Title of Project
Moore, P.P. and Hoashi-Erhardt	Northwest Center for Small Fruit Research	$32,419	2014-2015	Small Fruit Breeding in the Pacific Northwest
Moore, P.P. and Hoashi-Erhardt	Northwest Center for Small Fruit Research	$34,144	2014-2015	Enhanced Tools for Improving Root Rot Resistance in Red Raspberry
Moore, P.P. and Hoashi-Erhardt	Washington Red Raspberry Commission	$70,000	2014-2015	Red Raspberry Breeding, Genetics and Clone Evaluation
Moore, P.P. and Hoashi-Erhardt	Washington Strawberry Commission	$18,000	2014-2015	Genetic Improvement of Strawberry
Moore, P.P., K.K. Lanning and R.R. Martin	Washington Red Raspberry Commission	$8,750	2014-2015	Tracking the movement of RBDV
Moore, P.P. and Hoashi-Erhardt	Oregon Raspberry and Blackberry Commission	$4,400	2014-2015	Genetic Improvement of Raspberry
Moore, P.P. and Hoashi-Erhardt	Oregon Strawberry Commission	$4,400	2014-2015	Genetic Improvement of Strawberry
Moore, P.P. and Hoashi-Erhardt	Washington State Department of Agriculture	$32,109	2014-2017	Fresh Market Strawberry Pre-Breeding for Repeat Flowering and Powdery Mildew Resistance

Pending Support

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	Title of Project
Moore, P.P. and Hoashi-Erhardt	Washington Red Raspberry Commission	$75,000	2015-2016	Red Raspberry Breeding, Genetics and Clone Evaluation
Moore, P.P., K.K. Lanning and R.R. Martin	Washington Red Raspberry Commission	$8,239	2015-2016	Evaluation of Raspberry Bushy Dwarf Virus strains
Moore, P.P. and Hoashi-Erhardt	Washington Strawberry Commission	$37,000	2015-2016	Genetic Improvement of Strawberry

Washington Red Raspberry Commission
Progress Report Format for 2014 Projects

Project No:

Title: Red Raspberry Cultivar Development

Personnel: Michael Dossett, Research Scientist, Gosia Zdanowicz and Georgia Kliever, Technicians Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, PO Box 1000, 6947 #7 Hwy. Agassiz, BC, Canada, V0M 1A0, Michael.Dossett@agr.gc.ca Tel: 604-796-6084 Fax: 604-796-6133

Reporting Period: 2014

Summary of Accomplishments:
In 2014, the breeding program evaluated four machine-harvested trial plantings at the Clearbrook substation for a total of 297 plots. In addition, we planted a large machine-harvest trial planting of 230 plots (our largest to date), just over 4,000 new seedlings, performed 90 crosses, and made 38 new selections (nearly all with potential for RBDV resistance). Work on identifying methodologies and evaluating root rot resistance continued, with approximately 1400 plants propagated and sent to Puyallup for field comparison of our greenhouse screening results. These plants are part of a segregating population that should also facilitate identification of genetic markers for root rot tolerance.

Machine-harvest Evaluations
2010 Machine harvest planting: Several selections that machine-harvested well and had strong yields. Unfortunately, most of them also are susceptible to root rot. One bright spot in this planting is a selection from Andrew Jamieson's program in Nova Scotia: K02-15. This selection was dark, had nice flavor, machine-harvested well, and had yields similar to Meeker and Chemainus. It is a cross between 'Encore' and a sibling of 'Rudi'.

2011 Machine harvest planting: BC 3-14-12 was outstanding. Fruit are large, and yields are about 50% higher than Meeker, Chemainus and Saanich. It may be a little on the light side and it probably will be very susceptible to root rot. There was also a crumbly fruit problem that happened during propagation of some plants that went out, so this one will probably become a parent for yield and quality down the road rather than a candidate for release. Squamish (BC 92-9-15) was also a bright spot in this trial with large firm fruit and yields similar to industry standards that machine-harvested very nicely. It certainly has better root rot tolerance than 'Malahat', the main questions will be does it have enough root rot tolerance for anything other than early fresh market and will it have enough consistency to be considered as a dual-purpose variety. ORUS 1025-10 also looked good in this trial.

2012 Machine harvest planting: This was the first year of evaluation of this planting. There are several things that had beautiful fruit coming off the machine, but based on pedigree all are likely to be fairly susceptible to root rot.

What's in the Pipeline?
About 250 bare-root plants of BC 5-11-1 were planted this spring in grower trials in BC. This selection has Meeker-sized fruit of good quality. The plants have a fair degree of root rot tolerance but are susceptible to RBDV. The fruit machine-picks very cleanly. In trials at Clearbrook in 2012 and 2013 it didn't yield particularly well in the baby-crop year but was

exceptional in the year after. It will be picked on grower sites in the coming season as well as in a new machine-harvest planting at Clearbrook in 2015. If it still looks encouraging this summer, it will be slated for grower trials in Washington for the following year. The large machine-harvest planting established this spring included the first seedlings in our program that were selected from the machine-harvester. Many of the most promising selections from here were also planted in the machine harvest planting in Lynden this last spring. While we haven't seen large plots of any of these yet, I am fairly confident that there will be at least a few selections coming out of this that will get moved into grower trial fairly quickly. Finally, a little further down the line, but no less exciting are some of the selections that were made this last season. There was one particular cross that stood out as outstanding. I made 10 selections from this cross, and nine of them look like they have good potential to machine-pick. Both of the parents are RBDV resistant and both have some degree of root rot tolerance. What's more exciting is that these selections all have extremely firm fruit – firmer than any raspberry I've ever seen. The biggest reason for this is that they tend to have a combination of a very small receptacle/opening and large chunky druplets. The result is a berry that doesn't collapse because there isn't really much of a hollow/empty space on the picked berry to collapse, while the druplets also hold together extremely well.

This report is intended primarily as a summary. More information, including tables and complete trial results from 2014, as well as notes and comments on trial selections are available upon request.

Publications:

A number of publications are in preparation from results over the past year. The following are publications from 2014 to date:

<u>Peer-reviewed publications:</u>

Finn, C.E., B. Strik, B. Yorgey, P. Moore, **M. Dossett**, C. Kempler, T. Mackey, R.R. Martin, A. Jamieson, and G. Galletta. 2014. 'Sweet Sunrise' Strawberry. *HortScience.* 49:1088–1092.

Moore, P.P., W. Hoashi-Erhardt, B. Barritt, T. Sjulin, J.A. Robbins, C.E. Finn, R.R. Martin, and **M. Dossett.** 2014. 'Cascade Gold' Raspberry. *HortScience*. 49:358-360.

<u>Abstracts:</u>

Dossett, M., T. Forge, C. Koch, and C. Kempler. 2014. Resistance to *Phytophthora rubi* in wild North American red raspberry germplasm. American Society for Horticultural Science annual meeting. Orlando, FL.

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 funding comes from AAFC's Growing Forward 2 Initiative in the form of a proposal with two sections, "Berry Cultivar Development" and "Berry Germplasm Development." In this initiative, industry dollars are matched 1:3 with Federal government support. Since this is an umbrella project, I have broken down portions and time commitments by commodity for illustrative purposes.
Michael Dossett	**Current:** AAFC, WWRC, RIDC, LMHIA	$801,266	April 1, 2013 – March 31, 2018	50%	Red Raspberry Breeding for the Pacific Northwest
	AAFC, BCBC, WBC, LMHIA	$641,012	April 1, 2013 – March 31, 2018	40%	Blueberry Breeding for the Pacific Northwest
	AAFC, WSC, BCSGA, LMHIA	$160,253	April 1, 2013 – March 31, 2018	10%	Evaluating Strawberry Cultivars and Germplasm for BC and Northern Washington

2015 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

Continuing Project Proposal **Proposed Duration:** (3 years)

Project Title: Red Raspberry Cultivar Development

PI: Michael Dossett
Organization: BC Blueberry Council
Title: Research Scientist
Phone: 604-796-6084
Email: Michael.Dossett@agr.gc.ca
Address: C/O Pacific Agri-Food Research Centre
Address 2: 6947 Hwy #7, PO Box 1000,
City/State/Zip: Agassiz, BC V0M 1A0

Cooperators: Pat Moore, WSU Puyallup
Chad Finn, USDA-ARS, Corvallis
Nahla Bassil, USDA-ARS, Corvallis
Tom Forge, Nematology/Plant Pathology AAFC
Andrew Jamieson, Berry Breeder AAFC Kentville NS

Year Initiated __2013__ Current Year 2015 Terminating Year 2015

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

Other funding sources: Funding for the raspberry portion of the breeding program is also being solicited from the BC Raspberry Industry Development Council. The total industry cash contribution then is being used as matching funds leveraged 1:3 for a federal government grant that will supply the bulk of program funding. More details on this are provided on the page following the budget and budget justification.

Description: This project is to support the continued effort to breed raspberry cultivars adapted to the PNW. Chemical pest control measures are becoming increasingly unavailable, making genetic resistance and tolerance more important. Breeding for 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 habit 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. In April 2012, AAFC announced that it was cutting support for the program with the expectation that local industries pick up the slack. This proposal aims to keep the program running and continue the improvement and evaluation of germplasm in which the Washington and BC raspberry industries have invested heavily over the past several years.

While there are currently 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. One of the strengths of the BC program is the firmness and quality of its selections. 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. Over the next few years, AAFC has committed to providing office and lab space in support of the continuation of this program, as well as limited greenhouse and field space and staff support. While this means that the cost of continuing to staff and run the program has risen dramatically, this project will ensure that the investments of time and money already made towards the program will not be lost and that efforts can continue.

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 currently 3.5 years into a 5 year funding program called Growing Forward 2. 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 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 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. This is in collaboration with Pat Moore, and Nahla Bassil, testing new markers, and then validating those markers across breeding populations to assess their utility. 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. The populations have already been screened for aphid resistance. Screening for root rot resistance has started in the greenhouse and will continue over the next few winters in addition to planting in a field with heavy pressure in Puyallup, WA. Testing for RBDV infection will be an ongoing process.

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.

References:

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

	2015	2016	2017
Salaries[1/]	$	$	$
Time-Slip	$10,000	$	$
Operations (goods & services)	$2,000	$	$
Travel[2/]	$	$	$
Meetings	$	$	$
Other	$	$	$
Equipment[3/]	$	$	$
Benefits[4/]	$	$	$
Total	**$12,000**	**$**	**$**

The costs we are asking WRRC to support represent approximately 1/4 of the red raspberry portion of the industry contribution needed for the next cycle of funding. We have allocated this primarily to student labor for field planting, plot maintenance, and harvest, as well as some operational costs towards contracting for mechanical harvesting of plots ($100/hour for machine and driver). Hiring students for the summer period costs approximately $10,000/student. With the leveraged support, the budget we are proposing to WRRC will cover the cost of contracting the machine harvester and hiring a summer crew of four students (May 1 – August 30) to work on planting and maintaining plots (weeding, some pruning, trellis building and take down, etc.) before and after the fruiting period as well as harvesting/weighing fruit from the plots during the period from late June to early August. All other project costs including travel, supplies, scientist salary, overhead, etc., will be coming from dollars contributed by BC industry associations. We anticipate similar requests in the coming years, but have only filled in 2015 on this proposal as it is supposed to be the last year of a 3 year proposal started in 2013.

Budget Justification

[1/]Specify type of position and FTE.

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

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

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

Other funding sources:

All amounts are requested funds for the coming fiscal year and are pending final approval. Funding covers all costs for the salary for the scientist, hiring student labor, materials and supplies, land rental for plot space in Abbotsford (raspberries and strawberries), travel and contract costs for mechanical harvesting, winter pruning/tying, and some land prep.

Raspberries (50% Effort, $43,315 needed)**:**

BC Raspberry Industry Development Council	$31,315
Washington Red Raspberry Commission	$12,000

Blueberries (40% Effort, $33,847 needed)**:**

BC Blueberry Council	$28,847
Washington Blueberry Commission	$5,000

Strawberries (10% Effort, $5,926 needed)**:**

BC Strawberry Growers Association	$3,426
Washington Strawberry Commission	$2,500

Government of Canada – Federal Matching Dollars: $249,263

Washington Red Raspberry Commission
Progress Report 2014 (third year)

Title: Regional On-farm Trials of Advanced Raspberry Selections

Personnel:
PI: Tom Peerbolt –Peerbolt Crop Management.
Co PIs: Chad Finn – USDA-ARS; Pat Moore – WSU; Julie Enfield – Northwest Plants

Reporting Period: 2014

Accomplishments:

Infrastructure developments to date

- Established grower cooperator network and have three successive trial plantings in the ground (see listings on next page)
- Developed Microsoft Access database for organizing, archiving and retrieving all the data
- Developed yearly timeline for trial activities.
- Developed protocols for consist evaluation of trials and site visits.
- Established network between participating growers, propagators, breeders, and other industry and commission participants.
- Developed draft overall budget for determining annual costs for an ongoing program.
- Working on initial arrangements with British Columbia industry for establishing a joint on-farm trial program.

Information Products produced to date

- First cultivar/selection factsheet handout (see attached PDF)
  - *Will be produced annually.*
  - *Plan to attach to next WRRC newsletter*
  - *Will also attach to upcoming Small Fruit Update*
- **First annual Variety development Small Fruit Update**
  - *Planning on producing annually. Costs covered by numerous sources.*
  - *Linked to www.berriesNW.com website.*
  - *Posted on the WRRC website.*

2014 Plantings of Advanced Processed Raspberry Selections

Number of plants per trial per farm

	WSU 1980	WSU 2122	WSU 2166	WSU 2188
Dobbins Farm, Woodland	79	100	100	39
Enfield Farms, Lynden	45			
Maberry Farms, Lynden	42	200	160	11
Minaker Farms, Everson	125	250	250	125
RBO Farm, Jefferson, OR		10		
Sturms Farm, Corbett, OR		100	85	

2013 Plantings of Advanced Processed Raspberry Selections

Number of plants per trial per farm

	Lewis	BC 92-9-15 (Squamish)
Dhaliwal Farm, Lynden	250	250
Ehlers Farm, Lynden	200	200
Enfield Farms, Lynden	70	
Minaker Farms, Everson	250	

Sakuma Farms, Mt. Vernon	12	12
Sturms Farm, Corbett, OR	100	100

2012 Plantings of Advanced Processed Raspberry Selections

Number of plants per trial per farm

	WSU 1507	WSU 1912	WSU 1948	Rudi
Enfield Farms, Lynden	250	250	250	250
Minaker Farms, Everson	225	225	225	225
Sakuma Farms, Mt. Vernon		200	200	200
Sturms Farm, Corbett, OR	150	275	175	

2014 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

Project Proposal **Proposed Duration:** (1year)

Project Title: Evaluating the Feasibility of Coordinated Regional on-farm Trials of Advanced Raspberry Selections—Fourth Year

PI:
Tom Peerbolt
Organization: Peerbolt Crop Management
Title: Co-owner and Senior Researcher
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Email: tom@peerbolt.com
Address: 5261 North Princeton St.
City/State/Zip: Portland, OR 97203

Co PIs
Chad E. Finn – USDA-ARS-HCRU, Corvallis, OR
Patrick Moore – Washington State University, Puyallup, WA
Julie Enfield – Northwest Plants/Enfield Farms, Lynden, WA

Year Initiated 2012 Current Year 2014 Terminating Year 2015

Total Project Request: $11,200

Other funding sources:
Agency Name: Northwest Center for Small Fruit Research
Amt. Requested/Awarded: $32,554
Notes: This is a similar project that will allow us to also test black raspberries and fresh market caneberries of all types and disseminate testing information over a larger geographical area and to a larger audience.

Description: Organize and put in place a pilot network of regional on-farm grower trials for evaluating raspberry advanced selections issuing from the USDA-ARS/OSU breeding program in Corvallis and the WSU breeding program in Puyallup. The goal is to combine public and private resources in ways that would accelerate the commercialization of our genetic resources. This request is for the fourth year of this project. Over the first three years the grower/cooperator network has been developed; one, two and three year old plantings have been established; the infrastructure has been created for collecting, recording and distributing trial information. The 2015 season will be the fourth season of WRRC funding and be the first year that a fully mature harvest will be taken off the first year's (2012) trials.

Justification and Background:
The northwest raspberry breeding programs have been a cornerstone of the industry's success. Its ability to produce cultivars of commercial value is crucial to continued success. Global competition is increasing and public funding for these programs at our land grant institutions is under increasing budget constraints.

This program could strengthen the breeding programs by:

- Giving support to the existing research-station-based field trials by adding a strong, natural link that would improve the present method of sending advanced selections on to the propagators to be multiplied for grower trials.
- Decreasing the time needed to evaluate the commercial potential of selections.
- Increasing the industry-wide knowledge of new releases potential before they are released.
- Increasing the breeding programs and industry's ability to effectively manage its genetic resources using intellectual property tools (e.g. plant patenting and plant breeders' rights) by having information on a cultivar's potential well in advance of its release and patenting.

This program could support the growers by:

- Improving the quality and quantity of information they have for business planning.
- ▪ Currently, advanced selections are tested and new cultivars are released based on limited knowledge of their overall commercial potential and viability under various northwest growing conditions. This system forces the grower to either make a decision to plant a new cultivar based on inadequate data, or delay a decision for years until an adequate track record has reduced the risk level.
- Providing new communication links between the growers, nurseries and plant breeders.
- Allowing growers to actively participate in selection evaluations within established protocols and without needing to invest their own resources to pay for the plants and all the planting costs.

This program could strengthen the propagators and wholesale nurseries by:

- Improving their decision-making methods and reducing their risk.
- ▪ The present system puts the propagators/wholesale nurseries in the position of guessing how many of which selections and new releases to produce. This has led to economic losses to the nurseries caused by over and/or under production of material. It has created a disincentive for the wholesale nurseries to make available or test new products.
- Providing them with objective evaluations of new material under a variety of growing conditions to pass on to potential customers.

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:

- Organize and put in place a pilot network of regional on-farm grower trials for evaluating raspberry advanced selections issuing from the USDA-ARS/OSU breeding program in Corvallis and the WSU breeding program in Puyallup.
- Place trials on farms located in a variety of regional growing conditions. This network would connect growers, commodity commission contractors, wholesale nursery propagators, public small fruit breeders, and small fruit researchers for the purposes of:
    - 1) Improving the quality and breadth of information available on advanced selections,
    - 2) Improving the efficiency of this information's distribution to the grower/processor base.

The overall goal of the project is to combine public and private resources in ways that would accelerate the commercialization of our genetic resources. All objectives are included in 2015.

Procedures:

Review of initial project guidelines

- Tissue culture plants will be used.
- Maximum of 5 red raspberry selections (processed, but could include some fresh selections).
- Minimum of 3 grower sites per selection per year.
- Site guidelines would be representative of the major northwest growing regions including:
    - At least two sites in Northern Washington and one in SW Washington or Oregon.
- Maximum number of plants per selection per trial of machine harvested raspberries would be 1000 plants to produce enough fruit for processing potential. This could be considerably less depending on site and consensus of participants as to the size trial needed.
- Minimum number of plants could be as low as 10 for a fresh market or hand-picked trial.

Year four (2015) procedures

- Establish new plantings following procedures similar to those used in years one, two and three (2012 - 2014).
- Spring evaluations will be made of plant health/winter damage of the previously established plantings.
- Evaluations will be made of the first and second full harvest of the years of the 2012 and 2013 plantings.
- Evaluations will be made of the initial (baby) harvest of the year two (2014) plantings.
- The 2012 plantings will have reached the end of their evaluation period and they will be removed after this year's harvest.
- Evaluations will be made in the fall to determination whether to continue for another year's data of 2013 plantings.
- Advisory group will be communicating as needed to coordinate activities.
- Administrator will be giving periodic updates to participants. Disseminating and archiving information as needed.

Grower/cooperator arrangements

- Testing agreements would be created and approved by WSU (or WSURF) and by UDSA.
- Growers would sign testing agreements that would include: on-site visits by other growers and researchers (arranged and agreed to in advanced); participation in the evaluation process; and a testing agreement which includes 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 are detailed above in the Justification section of this proposal.
- The results be transferred to users by the Administrator who 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'.

References: none.

Budget:

	2015	2014	2015
Salaries[1/]	$5,000	$	$
Travel[2/]	$2,200	$	$
Outreach[3/]	$1,500	$	$
Other (Propagator payments**)**[4/]	$2,500	$	$
Total	**$11,200**	**$**	**$**

Budget Justification

[1/]Specify type of position and FTE. Administrator of project at 10% FTE

[2/]Provide brief justification for travel requested. Travel and related expenses to meet with growers and propagators, deliver plants, check plantings, attend meetings and workshops.

[3/]Outreach will be accomplished by 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/]These funds will be paid out by the Commission from invoices from the propagators.

2015 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

Project Title: Development of Biologically-based RNAi Insecticide to Control Spotted Wing Drosophila

PI: Man-Yeon Choi
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Title: Research Entomologist
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Address: 3420 NW Orchard Ave.
City/State/Zip: Corvallis/OR/97330

Co-PI: Robert R. Martin
Organization: USDA-ARS-HCRL
Title: Research Pathologist
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Address: 3420 NW Orchard Ave.
City/State/Zip: Corvallis/OR/97330

Cooperators: Dr. Jana Lee, Research Entomologist

Year Initiated 2015 **Current Year** 2015 **Terminating Year** 2018

Total Project Request: Year 1 $10,000 Year 2 $10,000 Year 3 $10,000 Year 4 $10,000

Other funding sources: *(If no other funding sources are anticipated, type in "None" and delete agency name, amt. request and notes)*
Agency Name: Will submit to OBC, WBC, and ORBC

Amt. Requested/Awarded: *(retain either requested or awarded and delete the other)*
Notes: Will request OBC, WBC, and ORBC ($10,000 each).

Project Description: Our research goal is to develop RNA interference (RNAi)-based biological insecticide as a chemical insecticide alternative to control spotted wing drosophila (SWD) in berry crops and small fruits. For the long-term goal specific our objectives are focused on the screening of potential RNAi targets through gene identification and bioassay from SWD. Once developed the RNAi target and tool can be adapted to control a plethora of other small fruit pests through specific RNAi delivery. The RNAi-based insecticide should be applied with non-transgenic applications such as feeding and/or spray with attractants, and thus stop Drosophila development. Specific outcomes from this project are expected to have potential RNAi target(s) that can be developed for a biologically-based insecticide as a chemical insecticide alternative to control SWD and other pests of small fruits.

Justification and Background:
Since the first outbreak in California 2008, Spotted Wing Drosophila (SWD) has spread across the U.S., Canada and Europe [1, 2]. This destructive pest oviposits and has larval development in a broad range of small fruit crops including almost all of the berry cultivars, cherries, grapes as well

as other ripening fruits. The estimated economic impact from crop yield loss, drop in market value, and higher management cost is hundreds of millions of dollars annually in the U.S. alone, and increasing [3, 4]. To control SWD, conventional chemical insecticides such as organophosphates and pyrethroids are applied, which carry non-target side effects on pollinators, beneficial insects, chemical residue, human health, and environmental burden [5, 6]. Furthermore a continuous spraying of the chemical insecticides for an extended period will result in the development of insecticide resistance in SWD. Thus, there is a need for an alternative approach for conventional and organic fruit producers. Alternative management strategies such as mass trapping using attractants, biological, and cultural control methods are being applied and under development, but not effective enough to replace the few major chemicals used. Thus the need to develop new target control agents that will lead to biologically-based pesticides in the field.

RNA interference (RNAi) represents a potentially new direction for insect pest control. RNAi is the specific down regulation or blocking the expression of one or more specific genes, that is a post-transcriptional gene-silencing mechanism. This action is induced by the introduction of double-stranded RNA (dsRNA) into a cell [7], resulting in degradation of a target messenger RNA (mRNA). Since the first report of RNAi in the plant [8], it has been exploited for various applications ranging from investigation of specific gene function to gene knockdown effects in plants and animals including insects. RNAi technology is a valuable tool that has led to the development of new class of insecticide to control insect pests. Although RNAi technology has many technical challenges, RNAi for insect control represents a new direction for insect pest management. In the past ten years, the application of RNAi techniques has progressed rapidly, and shows great potential for novel insect pest control alternatives because it poses little or no negative impact on the environment or beneficial insects. This technology is being developed for practical and commercial use to control fire ants [9], and the citrus psyllid, which is the vector of citrus greening disease [10].

Relationship to Commission Research Priorities: Prevention and Management of Spotted Wing Drosophila and other insect pests which are related in WRRC's research priorities #1 and others.

Objectives: Successful application of RNAi to pest management requires two key factors: 1) <u>selection of suitable target gene(s)</u> inducing a high level of gene interference or silencing, and 2) <u>development of a suitable delivery method</u> into target pests. Therefore, the screening of RNAi target genes from the specific pest is a critical initial step, and important to screen multiple RNAi candidates to improve the chance of identifying an effective RNAi target. The *long-term goal of this research is to develop non-transgenic RNAi-based insecticide* to control SWD in berry crops and small fruits. In order to achieve the long-term goal *specific objectives* are:

1. Select thirty genes in SWD from neurohormones and receptors involved in critical physiological functions during larval development and in the adult, and other genes involved in essential cellular activity (Yr. 1)
2. Identify target genes from SWD, and design dsRNA sequences of these genes and green fluorescence protein (GFP) as a control gene (Yr. 1 &2).
3. Inject RNAi into adult flies and monitor RNAi impacts (*i.e.* fecundity or mortality) on SWD (Yr.2 &3).
4. Feed RNAi selected into larvae and/or adults, and monitor RNAi impacts on SWD (Yr. 3-4).

Procedures: PI has expertise on insect RNAi and published research results in several peer-reviewed papers [9, 11] and the research magazine (USDA-ARS, 2014) [12] that demonstrated the selection of RNAi targets, construct dsRNA, micro-injection and bioassay in insect pests. In addition, those research results have been submitted for patent applications and awarded an RNAi patent [13] to develop RNAi control method, and are being developed for practical use. Therefore, PI is well-positioned to conduct all experimental procedures, and supervise technical assistants or graduate students for this project.

1) Identify potential RNAi target genes: Based on *D. melanogaster*'s genome sequences and information on gene function, we will employ a BLAST search with the published SWD genome (http://spottedwingflybase.oregonstate.edu) to identify homologous genes in SWD. Using routine molecular biology techniques and software, specific primers and/or degenerate primer set designed with 5'-T7 promoter appended will be designed to amplify partial lengths between 200- 400 nucleotides. Once confirmed the sequence DNA fragments will served as the template for dsRNA synthesis using a dsRNA synthesis kit. With PI's molecular biology knowledge and experience this approach is expected to be straightforward without possible pitfalls.

2) Evaluate RNAi impact(s) on SWD: DsRNAs of each target SWD gene and GFP will be dissolved in RNase free water and injected into pupal or adult stages of SWD using a nanoliter injector. PI has experience with micro-injecting dsRNA into small insects such as ants. After injection SWD will be monitored for negative impacts including mortality, longevity, fecundity and other parameters. Dr. Lee's laboratory has developed a system to monitor longevity and fecundity of flies. Dr. Martin's laboratory has experience and tools to investigate the silencing of RNAi-targeted genes using PCR. Once we identify best RNAi target genes, feeding assays will be conducted if incorporated into a bait and kill approach.

3) Screening RNAi targets of SWD: For adult feeding assays, various dsRNA concentrations determined from the injection experiment will be mixed in a dry bread yeast. The mixed yeast with dsRNA material will be sprayed on the surface of the artificial diet in a petri-dish to allow adult flies to feed in the cage. After feeding, flies will be monitored for phenotypic changes, and verified for gene silencing as described above. If necessary, we will try the larval feeding assays, the same concentration of the dsRNA will be added in the diet, and monitored for larval mortality and developmental rates, and gene silencing.

Available Facilities/major Instrumentation/Equipment: We have fully available and/or accessible equipment for molecular biology, RNAi bioassay and injection, and insect rearing facilities in USDA-ARS-HCRL.

Anticipated Benefits and Information Transfer: At the completion of these studies we expect to have identified potential RNAi target(s) that can be used to develop a biologically-based insecticide as a chemical insecticide alternative to control SWD and other pests of small fruits. We also expect to identify specific physiological impacts from RNAi treatments on SWD. Thus, outcomes are not only expected to address specific questions in RNAi research for SWD control, but also to have fundamental impacts for the application of RNAi for biological pest control.

References:

1. Hauser, M., *A historic account of the invasion of Drosophila suzukii (Matsumura) (Diptera: Drosophilidae) in the continental United States, with remarks on their identification.* Pest

Manag Sci, 2011. **67**(11): p. 1352-7.
2. Rota-Stabelli, O., M. Blaxter, and G. Anfora, *Drosophila suzukii.* Curr Biol, 2013. **23**(1): p. R8-9.
3. Beers, E.H., et al., *Developing Drosophila suzukii management programs for sweet cherry in the western United States.* Pest Manag Sci, 2011. **67**(11): p. 1386-95.
4. Goodhue, R.E., et al., *Spotted wing drosophila infestation of California strawberries and raspberries: economic analysis of potential revenue losses and control costs.* Pest Management Science, 2011. **67**(11): p. 1396-1402.
5. Lee, J.C., et al., *The susceptibility of small fruits and cherries to the spotted-wing drosophila, Drosophila suzukii.* Pest Manag Sci, 2011. **67**(11): p. 1358-67.
6. Lee, J.C., et al., *In Focus: Spotted wing drosophila, Drosophila suzukii, across perspectives.* Pest Manag Sci, 2011. **67**(11): p. 1349-51.
7. Fire, A., et al., *Potent and specific genetic interference by double-stranded RNA in Caenorhabditis elegans.* Nature, 1998. **391**(6669): p. 806-11.
8. Ecker, J.R. and R.W. Davis, *Inhibition of gene expression in plant cells by expression of antisense RNA.* Proc Natl Acad Sci U S A, 1986. **83**(15): p. 5372-6.
9. Choi, M.Y., et al., *Phenotypic impacts of PBAN RNA interference in an ant, Solenopsis invicta, and a moth, Helicoverpa zea.* J Insect Physiol, 2012. **58**(8): p. 1159-65.
10. Hunter, W.B., et al., *Advances in RNA interference: dsRNA Treatment in Trees and Grapevines for Insect Pest Suppression.* Southwestern Entomologist, 2012. **37**(1): p. 85-87.
11. Choi, M.Y. and R.K. Vander Meer, *Ant trail pheromone biosynthesis is triggered by a neuropeptide hormone.* PLoS One, 2012. **7**(11): p. e50400.
12. Choi, M.Y. and R.K. Vander Meer, *Targeting Pheromones in Fire Ants*, in *USDA Agricultural Research*. 2014. p. 6-7.
13. Vander Meer, R.K. and M.Y. Choi, *Formicidae (Ant) control using double-stranded RNA constructs.* 2013.

Budget: This project is being submitted to the Oregon Blueberry Commission (OBC), the Washington Blueberry Commission (WBC), the Oregon Raspberry & Blackberry Commission (ORBC), and the Washington Red Raspberry Commission (WRRC). The goal is to obtain enough funding to hire a graduate student or post-doc fellow for this project. USDA-ARS base funds in Dr. Choi's programs will be used to fund additional technical support and supplies for the project.

Salaries:	
Graduate Student	$23,000
OPE (50%)	$ 2,000
Total Salary	$25,000
Supplies	$13,000
Travel to Commission Meetings	$ 2,000
Total Budget for Project 2015	**$40,000**

Funding Breakdown
WRRC, WBC, OBC, and ORBC ($10,000 each)
Washington Red Raspberry Commission Budget Request $10,000

Final Report

Project Number: 14C-3443-5371

Title: Use of a mycoinsecticide targeting novel SWD preimaginal life stages and potential synergism with spinosad

Personnel: Lynell Tanigoshi, Beverly Gerdeman and Hollis Spitler

Reporting Period: 2014

Accomplishments: Two field trials were performed during the 2014 harvest season on a WSU NWREC red raspberry field. The first trial was applied 1-2 August on the red raspberry 'Meeker' plots, using an over-the-row boom sprayer (Fig. 1). The second application was applied 30 August by hand to soil within rim traps designed to concentrate and confine late instar larvae dropping from berries as they search for pupation sites. The mycoinsecticide applications were repeated 2 weeks later. The funnel traps described in the 2014 proposal were replaced by fabric sleeves made from rowcover which facilitated larvae and berry dropping while allowing adequate airflow (Figs. 2 and 3).

Fig. 1. Over the row boom application of mycoinsecticides to red raspberry hills.

Fig. 2. Larvae and raspberries fall freely into the rim traps below for easy recovery. *Sleeves resemble ghostly figures!*

Fig. 3. Mycoinsecticides and conventional insecticides were watered into the rim trap area using a watering can.

The objectives of the trials were:

- Investigate the efficacy of a soil-applied mycoinsecticide against SWD preimaginal stages.
- Investigate efficacy of a foliar tank mix against SWD
- Investigate synergistic activity with tank-mixed spinosad + mycoinsecticide applied as a foliar SWD adulticide.

Treatment adjustments were necessary during the field trials as a result of the extended hot dry period and low SWD populations in the 'Meeker' variety. Foliar applications were replaced by drench applications of Danitol® and the granular Deadlock G® and trials were restricted to the late season varieties of red raspberry which were highly infested by 30 August. Applications consisted of field rates of 6 treatments (Table 1).

Insecticide/mycoinsecticide	Active ingredient
Deadlock G	zeta cypermethrin
Met52 + Entrust	*Metarhizium anisopliae* + spinosad
Botanigard	*Beauveria bassiana*
Danitol	fenpropathrin
Met52	*Metarhizium anisopliae*
Botanigard + Entrust	*Beauveria bassiana* + spinosad
UTC	

Table 1. Red raspberry mycoinsecticide/insecticide treatment list.

Two weeks following the applications, approximately 1 inch of soil was scraped from within each of the rim traps using a hand trowel. Soil was placed in plastic containers and returned to the WSU NWREC entomology laboratory where each soil sample was sieved through three screens: U.S. Series from coarse to fine, 8 (2.46 mm), 16 (1.18mm) and 25 (0.701mm). Puparia were collected with an artist's fine brush and surface sterilized in a 10% bleach solution for 1 minute. The pupae were then placed on paper towels to wick away excess moisture. Then into 1 oz plastic condiment cups lined with cotton moistened with de-ionized water and held in a humidifying chamber to encourage sporulation.

After 1 week, recovered pupae were observed and placed into 5 categories (Table 2). 1. Pupae = average number of pupae recovered from each of the 3 treatment replicates. 2. Suspect = average number of pupae exhibiting signs of disease, 3. Flies emerged = average number of adults that emerged from pupae while inside cup, 4. Viable pupae = appearing healthy and 5. Damaged/dead = pupae that died of unknown causes.

Results: Observations in 2014 found that SWD pupae can be infected in the field with *Metarhizium anisopliae*. 1,863 SWD pupae were recovered from the 21 total rim traps representing approximately 15.12 ft^2 of area in the red raspberry trial plots. Based on these figures, a conservative estimate of Appears a possibsynergy between a mycoinsecticide and Entrust..

Table 2. SWD red raspberry mycoinsecticide trial 2014

Treatment	Pupae	viable pupa	damaged/dead	flies emerged	suspect infected
Deadlock	20.7 ± 3.7 a	9.0 ± 1.5 a	9.7 ± 1.8 b	3.3 ± 0.7 b	17.0 ± 3.5 ab
Met52 + Entrust	25.3 ± 6.2 a	13 ± 2.5 a	18.3 ± 7.3 ab	7.7 ± 2.2 b	16.3 ± 3.5 ab
Botanigard	42.7 ± 6.3 a	23.7 ± 6.7 a	25.3 ± 2.3 a	20.0 ± 5.9 a	21.3 ± 2.2 a
Danitol	18.7 ± 5.2 a	21.0 ± 12.9 a	21.0 ± 5.3 ab	7.9 ± 3.0 b	9.0 ± 2.1 b
Met52	30.0 ± 9.7 a	18.3 ± 5.9 a	25.7 ± 3.3 a	4.3 ± 2.6 b	14.7 ± 4.4 ab
Botanigard + Entrust	35.7 ± 21.1 a	26.3 ± 11.6 a	11.3 ± 3.9 b	11.0 ± 2.6 ab	15.3 ± 3.4 ab
UTC	21.7 ± 2.3 a	23.0 ± 3.5 a	14.3 ± 4.6 ab	8.7 ± 3.3 b	12.7 ± 5.2 ab
P-value	0.74	1	2.33	3.25	1.03

Means within a column and followed by the same letter or with no letters, are not statistically different.

The results indicate problem areas for interpretation. There should be no suspect infected pupae in treatments, which were not mycoinsecticides, Deadlock, Danitol and the untreated. These results are preliminary and specimens will undergo further testing with acid fuchsin. Pupae will be squashed/teased apart and placed in a drop of water. A drop of dilute acid fuchsin in lactic acid will be dropped onto the insect and any fungal blastospores, hyphae, etc. will be stained red to verify a fungal infection.

Observations:

- Tank mixes of mycoinsecticides + spinosad had the lowest fly emergence.
- Deadlock G - lowest # of dead puparia
- Botanigard – highest # dead puparia

We have obtained 2015 USDA-NCSFR funding for a repeat mycoinsecticide trial. Modifications for the coming season will include a mulch substrate, rather than applying treatments to bare soil. Rates will be recalculated. Pupae will be recovered less than 1 week following soil applications.

2015 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

Project Title: Combining miticides and SWD controls into a season long effective program for red raspberry

PI: Lynell K. Tanigoshi
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Co-PI: Beverly Gerdeman
Washington State University
WSU Entomology Research Associate
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Address: WSU-NWREC, 16650 State Route 536, Mount Vernon, WA 98273-4768

Year Initiated 2014 **Current Year** 2014 **Terminating Year** 2016

Total Project Request: $11,657

Other Funding Sources: Seeking funding from Washington State Commission on Pesticide Registration.

Description: Serious economic levels of spider mites in red raspberry have occurred when exposed to carbamates, organophosphates and pyrethroids by stimulating reproduction through hormonal-like action. These compounds are also toxic to beneficial insects and especially to predatory phytoseiid mites (e.g., *Neoseiulus fallacis*), which assist in biological control of spider mite populations. Unfortunately, spotted wing drosophila, *Drosophila suzukii* (SWD), is p rimarily managed in red raspberry using pyrethroids and organophosphates, increasing the likelihood for potential mite outbreaks. Extended dry periods experienced in 2014 in northwest Washington promoted mite outbreaks that resulted in several reports of economic injury. Support from WSCPR will help growers develop a spider mite program that: 1. minimizes potential for flare-ups through early season tank mixes; 2. provides effective rescue treatments when necessary and 3. is compatible with their SWD control program and target market MRLs.

Justification and Background:
Washington red raspberry growers harvested a record 72.5 million pound crop in 2014, up nearly 7% over 2013 (Jenkins 2014). SWD is the most economically important pest of red raspberry and Washington State produces 90% of US red raspberries on nearly 10,000 acres with a farmgate value of approximately $40 million dollars. After a five-year battle with red raspberry's most economically damaging pest, growers have fallen into a comfortable prophylactic calendar program abandoning rational IPM methods to control SWD in red raspberry. To ensure a profitable crop, establishing a successful SWD control program is mandatory and current programs consist of minimal rotation between an organophosphate and pyrethroids. These effective controls however, can unintentionally stimulate spider mite populations and devastate beneficial insects, especially predatory

phytoseiid mites, which assist in controlling spider mite populations. An effective spider mite program is quickly needed if the long dry spells experienced this summer reoccur.

The two most economic species of spider mites on caneberries in Washington State are the twospotted spider mite, *Tetranychus urticae*, and the yellow spider mite, *Eotetranchus carpini borealis*. Yellow spider mites are the first species to emerge in spring, usually April and can result in severe damage to fruiting lateral foliage (Tanigoshi et al. 2003). However growers have five registered miticides (4 different IRAC MoA) with two additional miticides pending registration. A contact and mite growth regulator tank mix targeted for early season spider mite populations will provide long residual while minimizing chances for explosive populations during harvest. Tank mixing a SWD insecticide with a selective miticide like Acramite® offers favorable MRLs and reduces applications. Developing possible rotational schemes will provide growers with practical methods to manage low to high spider mite populations, early, mid and late season.

Relationship to WRRC Research Priority: #1 priorities, Mite Management and Management Options for Control of SWD.

Objectives:

- Evaluate spider mite impact in SWD conventionally managed commercial red raspberry fields.
- Evaluate grower/cooperator SWD programs in conventionally managed red raspberry fields.
- Introduce the D-Vac insect vacuum to growers as a monitoring tool for SWD and beneficial insects.

Procedure:

Spider mites

A grower's SWD/spider mite program will be evaluated through randomly sampling 25 leaflets. The sample will be processed with a mite-brushing machine (Henderson & McBurnie 1943) onto a 13 cm diameter glass plate coated with a fine layer of liquid detergent. Estimated average number of motile spider mites and predatory mites per leaflet will be determined with a dissecting microscope throughout the red raspberry harvest and postharvest seasons. Side effects of the SWD insecticides on pest and beneficial populations will be especially monitored.

SWD program

Select commercial grower/cooperator programs for SWD will be evaluated during the red raspberry season through weekly sampling for SWD. Weekly samples will involve three methods:

Bioassays: A random sample of 20 leaflets will be collected and returned to WSU NWREC at 1, 3 and 5 DAT following the grower's weekly calendar spray. Leaflets will be divided among 20 Petri dishes. Five females will be added to each dish and mortality will be recorded at 24 hours to determine foliar residual activity.

Berries: A weekly random sample of 100 berries will be taken to evaluate presence/absence of SWD infested berries. Berries will be placed upright on a white paper-lined lunch tray, two inches apart. Berry trays will be placed in an insect-proof screen cage. After 24 hours, berries will be observed for excessive leakage and breakdown. Berries experiencing rapid breakdown at 24 hours will be scored as + for the presence of SWD. Percent infested will be recorded.

D-Vac Vacuum Insect Net: Growers will be introduced to the D-Vac (Dietrick 1961) Model-122, as an effective tool for determining presence of SWD in a raspberry field and effects of their SWD management program on beneficial insects. Each week, three 30-second vacuum samples will be taken per field. Each sample will be placed into a ziplock and returned to the WSU NWREC laboratory for evaluation using a dissecting microscope. SWD numbers will be recorded. Beneficial insects will be identified and numbers recorded. Results will provide growers with efficacy of their current program and effects on beneficial insect populations in their fields. Emphasis will be placed on hands-on training of commercial farm scouts with the D-Vac and in-field evaluation of samples.

Anticipated Benefits and information Transfer: This study will evaluate current industry standard SWD management programs in western Washington red raspberry fields. It will provide growers with information on residual efficacy of their insecticides and spray intervals. At the same time, it will provide growers with information on effects of their SWD program on spider mite populations and beneficial insects and predatory mites in their fields. Adoption of the D-Vac will provide scouts with a reliable sampling tool to evaluate SWD population levels. Results will be presented at local and regional grower meetings, Whatcom County Ag Monthly Newsletter and on the WSU NWREC Entomology website.

References:

Dietrick, E. J. 1961. An improved backpack motor fan for suction sampling of insect populations. Journal of Economic Entomology, 54: 394-395.

Jenkins, D. 2014. Washington's red raspberry crop breaks record. *Capital Press* retrieved 18 November 2014, from http://www.capitalpress.com/Orchards/20141024/washingtons-red-raspberry-crop-breaks-record

Tanigoshi, L. K., T. A. Murray and B. S. Gerdeman. 2003. Spider mites on red raspberry. WSU. Extn. Bull. 1959E. 7 pp.

Proposed Budget:	**2015**
Salaries[1]	$6,126
Non-student temporary	$2,000
Operations (goods & services)	$200
Travel[2]	$500
Equipment	$0
Employee benefits[3] 2 months for Research Technician @ 40.04%	$2,453
NWREC time-slip employee at 18.9%	$378
Total	**$11,657**

Budget Justification

[1] Two month salary at 100 FTE for Research Technician

[2] Mileage at $0.56/mile to field sites

[3] Employee benefits 2 months for Research Technician @ 40.04% ($2,453)
NWREC time-slip employee at 18.9% ($378)

Project Number: 13C-3419-7297

Title: Perennial Weed Control in Red Raspberries

Personnel: Timothy W. Miller, WSU Mount Vernon NWREC
Carl R. Libbey, WSU Mount Vernon NWREC

Reporting Period: 2013-14

Accomplishments: The new herbicide trial was conducted at the Mukhtar Singh Farm near Lynden, WA. Three other raspberry trials were conducted during 2014: an IR-4 efficacy and crop safety trial for saflufenacil, a Zeus (sulfentrazone) timing trial, and cane burning/fruit quality trial at WSU NWREC. Data for the new herbicide trial are reported here and will be available at the red raspberry portion of the Northwestern Washington Small Fruit Conference in Lynden in December, 2014.

Materials and Methods:

The trial was conducted on established 'Meeker' red raspberry near Lynden, WA. Products were applied at two timings: at time of primocane burning (PRIMO, 6-inch primocanes) and to 3-ft tall primocanes (POST). Herbicides were applied March 27 (PRIMO) and May 20 (POST), 2014 using a CO_2-pressurized backpack sprayer. Herbicides and rates are provided in Tables 1 through 4. Primocane injury and weed control were evaluated April 10 and 28, May 7, and June 9. Berries were sampled by hand on July 7. The design was a randomized complete block with three replicates.

Results:

There was no visible floricane injury resulting from any treatment (data not shown). Gramoxone and Treevix PRIMO applications gave satisfactory primocane control by the April 11 evaluation (Table 1). By early June, there was no significant growth reduction by herbicide treatment. Broadleaf weed control was uniform for all treatments in this trial, ranging from 73 to 100% control at all evaluation timings (Table 2). Plots scheduled to receive quinclorac POST were generally more weedy than plots receiving a PRIMO treatment; following quinclorac application, broadleaf weed control was similar across all treatments. Primary broadleaf weeds in the plots were common groundsel (*Senecio vulgaris*), fringed willow-herb (*Epilobium ciliatum*), dandelion (*Taraxacum officinale*), and wild buckwheat (*Polygonum convolvulus*). Quackgrass (*Elymus repens*) was present to some degree in most plots, ranging from 13 to 83% cover among all plots prior to herbicide application (Table 3). Most subsequent control ratings did not significantly differ, although it appears that Gramoxone was more effective in burning back emerged quackgrass than Treevix. Berry yield and fruit size was similar for all treatments (Table 4). The single sampling averaged about 600 g fruit per m of row. Fruit size ranged from 2.4 to 3.0 g/berry.

These results indicate that new herbicides tested in this trial were safe for established red raspberry. Alion combinations with Gramoxone gave effective broadleaf weed control, as well as initial burn of quackgrass. Treevix combinations were effective for primocane management and subsequent broadleaf weed control, and quinclorac, alone and in combination with other herbicides, should continue to be a high priority for ultimate registration in red raspberry.

Table 1. Primocane growth reduction following application of several herbicides in red raspberry (2014).

Treatment[a]	Rate	Timing	Primocane growth reduction[b] 4/10	4/28	5/7	6/9
	product/a		%	%	%	%
Alion + Gramoxone	5 fl.oz + 2 pt	PRIMO	83 ab	68 a-d	30 abc	2
Alion + Gramoxone	10 fl.oz + 2 pt	PRIMO	93 ab	58 bcd	10 bc	2
Treevix	1 oz	PRIMO	93 ab	73 a-d	53 abc	2
Treevix	2 oz	PRIMO	100 a	82 abc	65 ab	2
Alion + Treevix	5 fl.oz + 1 oz	PRIMO	100 a	83 abc	57 abc	0
Alion + Sinbar + Gramoxone	5 fl.oz + 1.5 lb + 2 pt	PRIMO	87 ab	82 abc	57 abc	2
Alion + simazine + Gramoxone	5 fl.oz + 2 qt + 2 pt	PRIMO	63 a-d	73 a-d	35 abc	2
Alion + diruon + Gramoxone	5 fl.oz + 2 lb + 2 pt	PRIMO	72 abc	60 a-d	28 abc	2
Treevix + Sinbar	1 oz + 1.5 lb	PRIMO	100 a	62 a-d	30 abc	2
Treevix + simazine	1 oz + 2 qt	PRIMO	95 a	50 cd	23 abc	2
Treevix + diuron	1 oz + 2 lb	PRIMO	100 a	68 a-d	42 abc	2
Quinclorac	12 fl.oz	POST	40 a-d	95 a	73 a	0
Quinclorac	1.5 pt	POST	0 d	90 ab	55 abc	2
(Alion + Gramoxone) fb Quinclorac	(5 fl.oz + 2 pt) fb 12 fl.oz	(PRIMO + PRIMO) fb POST	60 a-d	62 a-d	28 abc	2
Treevix fb Quinclorac	1 oz fb 12 fl.oz	PRIMO fb POST	43 a-d	38 d	8 bc	2
Sinbar fb Quinclorac	1.5 lb fb 12 fl.oz	PRIMO fb POST	25 bcd	83 abc	48 abc	2
Simazine fb Quinclorac	2 qt fb 12 fl.oz	PRIMO fb POST	0 d	88 ab	58 abc	2
Diuron fb Quinclorac	2 lb fb 12 fl.oz	PRIMO fb POST	13 cd	83 abc	67 ab	0

Means within a column and followed by the same letter, or not followed by a letter, are not significantly different ($P < 0.05$).

[a]Herbicides applied March 27 (6-inch primocanes) and May 20 (POST, 3-ft primocanes), 2014; “fb” = “followed by”.

[b]Perecent primocane burn is the level of primocane suppression visible in the plot compared to nontreated primocanes; quinclorac was not applied until May 20, 2014.

Table 2. Weed control following application of several herbicides in red raspberry (2014).

Treatment[a]	Rate	Timing	Weed control[b] 4/10	4/28	5/7	6/9	8/7
	product/a		%	%	%	%	%
Alion + Gramoxone	5 fl.oz + 2 pt	PRIMO	100 a	100 a	100 a	95 a	93 a
Alion + Gramoxone	10 fl.oz + 2 pt	PRIMO	100 a	100 a	100 a	100 a	100 a
Treevix	1 oz	PRIMO	97 a	90 ab	87 ab	88 a	82 a
Treevix	2 oz	PRIMO	98 a	98 a	100 a	100 a	98 a
Alion + Treevix	5 fl.oz + 1 oz	PRIMO	98 a	100 a	100 a	100 a	98 a
Alion + Sinbar + Gramoxone	5 fl.oz + 1.5 lb + 2 pt	PRIMO	100 a	100 a	100 a	98 a	97 a
Alion + simazine + Gramoxone	5 fl.oz + 2 qt + 2 pt	PRIMO	100 a	100 a	100 a	97 a	97 a
Alion + diuron + Gramoxone	5 fl.oz + 2 lb + 2 pt	PRIMO	100 a	100 a	100 a	100 a	100 a
Treevix + Sinbar	1 oz + 1.5 lb	PRIMO	98 a	100 a	100 a	98 a	100 a
Treevix + simazine	1 oz + 2 qt	PRIMO	93 a	85 ab	80 ab	82 a	88 a
Treevix + diuron	1 oz + 2 lb	PRIMO	98 a	93 ab	92 ab	92 a	83 a
Quinclorac	12 fl.oz	POST	83 a	92 ab	88 ab	80 a	78 a
Quinclorac	1.5 pt	POST	75 a	83 ab	82 ab	85 a	85 a
(Alion + Gramoxone) fb Quinclorac	(5 fl.oz + 2 pt) fb 12 fl.oz	(PRIMO + PRIMO) fb POST	98 a	98 a	100 a	98 a	98 a
Treevix fb Quinclorac	1 oz fb 12 fl.oz	PRIMO fb POST	85 a	77 b	73 b	85 a	85 a
Sinbar fb Quinclorac	1.5 lb fb 12 fl.oz	PRIMO fb POST	95 a	98 a	98 ab	97 a	97 a
Simazine fb Quinclorac	2 qt fb 12 fl.oz	PRIMO fb POST	78 a	98 a	98 ab	95 a	95 a
Diuron fb Quinclorac	2 lb fb 12 fl.oz	PRIMO fb POST	83 a	98 a	97 ab	93 a	88 a
Nontreated	---	---	0 b	0 c	0 c	0 b	0 b

Means within a column and followed by the same letter, or not followed by a letter, are not significantly different ($P < 0.05$).

[a]Herbicides applied March 27 (6-inch primocanes) and May 20 (POST, 3-ft primocanes), 2014; “fb” = “followed by”.

[b]Quinclorac was not applied until May 20, 2014.

Table 3. Quackgrass cover following application of several herbicides in red raspberry (2014).

Treatment[a]	Rate	Timing	Quackgrass cover[b]					
			Preburn	4/10	4/28	5/7	6/9	8/7
	product/a		%	%	%	%	%	%
Alion + Gramoxone	5 fl.oz + 2 pt	PRIMO	52	7	15	18	12	8
Alion + Gramoxone	10 fl.oz + 2 pt	PRIMO	33	5	8	13	7	5
Treevix	1 oz	PRIMO	53	47	60	73	52	33
Treevix	2 oz	PRIMO	60	57	60	65	53	35
Alion + Treevix	5 fl.oz + 1 oz	PRIMO	83	80	82	90	62	28
Alion + Sinbar + Gramoxone	5 fl.oz + 1.5 lb + 2 pt	PRIMO	83	20	23	38	12	43
Alion + simazine + Gramoxone	5 fl.oz + 2 qt + 2 pt	PRIMO	47	7	8	8	10	7
Alion + diruon + Gramoxone	5 fl.oz + 2 lb + 2 pt	PRIMO	65	13	17	37	25	13
Treevix + Sinbar	1 oz + 1.5 lb	PRIMO	35	33	33	32	5	3
Treevix + simazine	1 oz + 2 qt	PRIMO	13	13	13	25	13	20
Treevix + diuron	1 oz + 2 lb	PRIMO	42	42	45	48	32	25
Quinclorac	12 fl.oz	POST	65	65	58	65	47	32
Quinclorac	1.5 pt	POST	35	35	28	35	18	17
(Alion + Gramoxone) fb Quinclorac	(5 fl.oz + 2 pt) fb 12 fl.oz	(PRIMO + PRIMO) fb POST	28	2	3	10	5	5
Treevix fb Quinclorac	1 oz fb 12 fl.oz	PRIMO fb POST	35	35	35	35	25	12
Sinbar fb Quinclorac	1.5 lb fb 12 fl.oz	PRIMO fb POST	33	32	25	23	7	2
Simazine fb Quinclorac	2 qt fb 12 fl.oz	PRIMO fb POST	28	28	28	35	23	13
Diuron fb Quinclorac	2 lb fb 12 fl.oz	PRIMO fb POST	27	27	27	35	18	15
Nontreated	---	---	68	68	73	77	65	38

Means within a column and followed by the same letter, or not followed by a letter, are not significantly different ($P < 0.05$).

[a]Herbicides applied March 27 (6-inch primocanes) and May 20 (POST, 3-ft primocanes), 2014; “fb” = “followed by”.

[b]Percent quackgrass cover given for prior to herbicide application “preborn” and following herbicide treatment; quinclorac was not applied until May 20, 2014.

Table 4. Red raspberry yield and fruit size following application of several herbicides (2014).

Treatment[a]	Rate	Timing	Fruit yield[b]	Berry size[b]
	product/a		g/m	g/berry
Alion + Gramoxone	5 fl.oz + 2 pt	PRIMO	670	2.6
Alion + Gramoxone	10 fl.oz + 2 pt	PRIMO	658	2.7
Treevix	1 oz	PRIMO	698	2.5
Treevix	2 oz	PRIMO	717	2.7
Alion + Treevix	5 fl.oz + 1 oz	PRIMO	719	2.4
Alion + Sinbar + Gramoxone	5 fl.oz + 1.5 lb + 2 pt	PRIMO	733	2.6
Alion + simazine + Gramoxone	5 fl.oz + 2 qt + 2 pt	PRIMO	521	3.0
Alion + diruon + Gramoxone	5 fl.oz + 2 lb + 2 pt	PRIMO	601	2.7
Treevix + Sinbar	1 oz + 1.5 lb	PRIMO	829	2.7
Treevix + simazine	1 oz + 2 qt	PRIMO	754	2.5
Treevix + diuron	1 oz + 2 lb	PRIMO	869	2.6
Quinclorac	12 fl.oz	POST	563	2.9
Quinclorac	1.5 pt	POST	797	2.9
(Alion + Gramoxone) fb Quinclorac	(5 fl.oz + 2 pt) fb 12 fl.oz	(PRIMO + PRIMO) fb POST	611	2.9
Treevix fb Quinclorac	1 oz fb 12 fl.oz	PRIMO fb POST	811	2.7
Sinbar fb Quinclorac	1.5 lb fb 12 fl.oz	PRIMO fb POST	738	2.6
Simazine fb Quinclorac	2 qt fb 12 fl.oz	PRIMO fb POST	678	2.5
Diuron fb Quinclorac	2 lb fb 12 fl.oz	PRIMO fb POST	713	2.7
Nontreated	---	---	805	2.4

Means within a column and followed by the same letter, or not followed by a letter, are not significantly different ($P < 0.05$).

[a]Herbicides applied March 27 (6-inch primocanes) and May 20 (POST, 3-ft primocanes), 2014; “fb” = “followed by”.

[b]Fruit yield from 1 m of row, picked July 7, 2014; berry size calculated from the weight of 50 berries.

2015 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

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

Project Title: Testing herbicides for weed control in newly-planted red raspberries.

PI: Tim Miller
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Cooperators: These trials will likely be conducted at WSU Mount Vernon NWREC

Year Initiated 2015 **Current Year** 2015 **Terminating Year** 2015

Total Project Request: **Year 1** **$2,936** **Year 2** **$0** **Year 3** **$0**

Other funding sources:
Agency Name: British Columbia Raspberry Industry Development Council and the Oregon Raspberry and Blackberry Commission
Amt. Requested: **$5,872** ($2,936 from each)
Notes: Additional support for this project includes the herbicides, which are generally provided by the manufacturer. It is hoped that plant material will be donated by Norcal Nursery as in past trials (they have annually provided me with strawberry plants, and have provided raspberry plants for four trials).

Description: Weeds continue to be problematic in red raspberry production, particularly during the first two years of establishment. The only products registered for use in newly-planted raspberry are Chateau (flumioxazin, low rate), Gallery/Trellis (isoxaben), Snapshot 2.5 TG (trifluralin + isoxaben), Surflan (oryzalin), and simazine. Testing of new herbicides is necessary to gain new registrations. Products of interest are Stinger (clopyralid), Paramount (quinclorac), Treevix (saflufenacil), Zeus (sulfentrazone), Matrix (rimsulfuron), Sandea (halosulfuron), and Alion (indaziflam). Sequential applications of these products will be tested for efficacy on various weed species and for crop safety in this project.

Justification and Background:

Weed seeds are most likely to germinate in bare soil, which is most likely to be found in the establishment year of newly-planted raspberries. These raspberries are also considered to be the most sensitive to herbicides (with the possible exception of tissue-culture plants), due to their limited root systems and the stress that accompanies transplanting. While many weeds emerging during the initial year of raspberry growth are annual species, perennial weeds also frequently become established the first couple of seasons on a new raspberry block when raspberry plants are small and not as competitive. Often, these weeds are present in the field prior to transplanting baby raspberries. If not controlled when the infestation is relatively small, perennial weeds become increasingly difficult to kill, increasing herbicide and labor costs and becoming a major factor in reducing the longevity of raspberry plantings. Therefore it is of interest to gain registrations for herbicides that provide selectivity in young raspberries while also providing control of these annual and perennial weed species.

Most previous work at WSU Mount Vernon NWREC has resulted from testing new herbicides in established red raspberries. Reliable crop injury data resulting from applications of these products to newly-transplanted raspberry is needed to document that they are safe for this use. Products of interest to test for this use are Stinger (DowAgrosciences, set to enter IR-4 residue testing in established caneberries in 2014), quinclorac (Quali-Pro), Treevix (BASF), Zeus (FMC), Chateau (Valent), Matrix (DuPont), Sandea (Gowan), and Alion (Bayer). I am unaware of any weed management projects in raspberry currently being conducted in in Oregon, Idaho, or British Columbia.

Relationship to WRRC Research Priority(s): #3 Priority, Weed Management

Objectives: To test several non-labeled herbicides in various sequences or mixtures for weed control and crop safety in newly-planted red raspberries.

Procedures:

Plots will be established in spring 2015 at WSU Mount Vernon NWREC using two or three raspberry cultivars. Herbicide applications will be made preemergence (PRE), immediately following raspberry transplanting, and postemergence (POST), after initial growth of raspberry plants reaches about 2 feet tall. Weed control and crop injury will be evaluated periodically through the growing season. At the end of the growing season, raspberry canes will be counted, measured, and above-ground biomass recorded. Plants will be left in the ground through winter 2015-16, retreated during late-dormancy (March, 2016) and initial regrowth monitored through spring, 2016. Tissue-cultured raspberry plants will be transplanted into these research plots as available (Norcal, Enfield) to determine their sensitivity to the same herbicides being tested on transplanted roots.

Anticipated Benefits and Information Transfer:

If positive, data from this experiment will be used to support new herbicide registrations in raspberries for these products. The data resulting from these studies will be disseminated through extension bulletins and during grower meetings sponsored by extension faculty and the agricultural industry.

Budget:

	2015	2016	2017
Salaries[1]	$ 1,000	$ 0	$ 0
Time-Slip	$ 750	$ 0	$ 0
Operations (goods & services)[2]	$ 250	$ 0	$ 0
Travel[3]	$ 100	$ 0	$ 0
Meetings	$ 0	$ 0	$ 0
Other	$ 0	$ 0	$ 0
Equipment	$ 0	$ 0	$ 0
Benefits[3]	$ 836	$ 0	$ 0
Total	**$ 2,936**	**$ 0**	**$ 0**

Budget Details

[1]Salary for A/P scientific assistant Carl Libbey is completely funded by external grants.
[2]Operations (goods and services) include flags, spray accessories, and related office and field supplies.
[3]Travel is for plot establishment, maintenance, and data collection.
[4]Benefits (36.19% for A/P scientific assistant, $362; 63.2% for time-slip help, $474; total $836).

2015 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

New Project Proposal **Proposed Duration:** 6 years

Project Title: Comparison of Alternate- and Every-Year Production in Summer-Bearing Red Raspberry

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Co-PI: Suzette Galinato
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Cooperators: Jonathan Maberry, Maberry Packing LLC

Year Initiated 2015 **Current Year** 2015 **Terminating Year** 2020

Total Project Request: Year 1 $8,958 **Year 2** $11,269 **Year 3** $13,956
Year 4 $14,493 **Year 5** $16,965 **Year 6** $24,137

Other funding sources: *None at this time.*

Description:
Increasing costs and decreasing availability of labor are compromising the economic viability of commercial red raspberry production in western Washington. The grower community is in need of alternative production systems that minimize labor needs, maintain productivity, and are economically viable. This project addresses that need by evaluating the economic viability of alternate-year production relative to traditional every-year production systems. Specific sub-objectives of this projects are to: 1) Evaluate differences in plant productivity and yield between alternate- and every-year production systems; and 2) Complete a benefit-cost analysis to assess the on-farm net benefits of alternate-year production relative to traditional every-year production systems. Results of this project will be disseminated at conferences, field days, and through a Washington State University extension publication. Overall, this long-term project will provide valuable information regarding potential labor savings and the economic feasibility of this alternative system of red raspberry production.

Justification and Background:
The increasing cost of labor has become prohibitive for many growers of horticultural crops, including red raspberry (*Rubus idaeus*). Summer-bearing raspberry is particularly labor intensive, with annual pruning and tying of canes representing approximately 10% of total annual costs during established bearing years (personal communication with grower). Access to labor is also extremely challenging for growers. These issues demonstrate a need to investigate alternative production systems that reduce growers' dependency on labor. Alternate-year

production, which entails removal of spent floricanes and producing fruit on an every-other-year cropping cycle, represents one potential system that reduces labor associated with pruning and tying.

In Oregon, alternate-year production is practiced in 20-55% of ‘Marion’ blackberry fields (Strik, 1996). Average two-year yields are reduced by 10-30% relative to every-year production, but several advantages contribute to its adoption (Bullock, 1963; Martin and Nelson, 1979). Decreased labor costs, primary due to reduced pruning and training needs, as well as reduced pesticide usage and improved cold hardiness, are several of the advantages that contribute to the persistence of alternate-year production in blackberry (Bell et al., 1992). Minimal research on alternate-year production systems have been completed in red raspberry. Furthermore, no published research has been conducted in Whatcom County, which contributes approximately 93% of total production in Washington State (WRRC, 2013). In a six-year study performed in Vancouver, Washington, with ‘Meeker’ and ‘Willamette’, investigators found yield was reduced by 60% in an alternate-year system (Barney and Miles, 2007). However, it was not articulated if primocane suppression occurred during the course of the study, which can impact yield potential. Studies in New York have found yield reductions of only 30% over the long-term and these reductions can be partially offset through suppression of the first flushes of primocanes during fruiting years (Pritts, 2009).

Despite potential yield reductions, these systems may be economically viable given the current scenario of high labor costs and reduced labor availability. The increasing problems related to costs and availability of labor need to be addressed and this project proposes to address this need by systematically evaluating the costs, potential savings, and yield of summer-bearing raspberries produced using an alternate-year production system.

Relationship to WRRC Research Priority(s):
This project directly addresses the priority of investigating labor saving cultural practices, including alternate year systems.

Objectives:
The overall objective of this project is to evaluate the economic viability of alternate-year production for summer-bearing red raspberries growers in western Washington. Specific sub-objectives include: 1) Evaluate differences in plant productivity and yield between alternate- and every-year production systems; and 2) Complete a benefit-cost analysis to assess the on-farm net benefits of alternate-year production relative to traditional every-year production systems. Given we are proposing to establish this project in 2015, our goal for this funding year is to establish the field experiment, initiate collection of economic data, and begin implementing treatments.

Procedures:
Treatment plots of ‘Meeker’ raspberry will be established in the spring of 2015 with a commercial grower located in Whatcom County, Washington. The proposed experimental design is a randomized complete block, with two treatments (alternate- and every-year production) replicated five times. Experimental units will be two rows randomized within a block (**Fig. 1;** row length to be determined with grower cooperator). In 2015 and 2016, both treatments will be treated the same and a small crop will be harvested in 2016. After fall leaf

drop, every-year treatment plots will be pruned and trained according to commercial practice. Alternate-year treatment plots will be mowed and fruit production will be prevented in 2017. Fall mowing of spent floricanes will be repeated in 2018 and 2020, preceded by three-to-four spring applications of primocane suppressive herbicides during bearing years. Every-year treatment plots will be managed according to commercial standards throughout the duration of the project, which will entail annual pruning and tying.

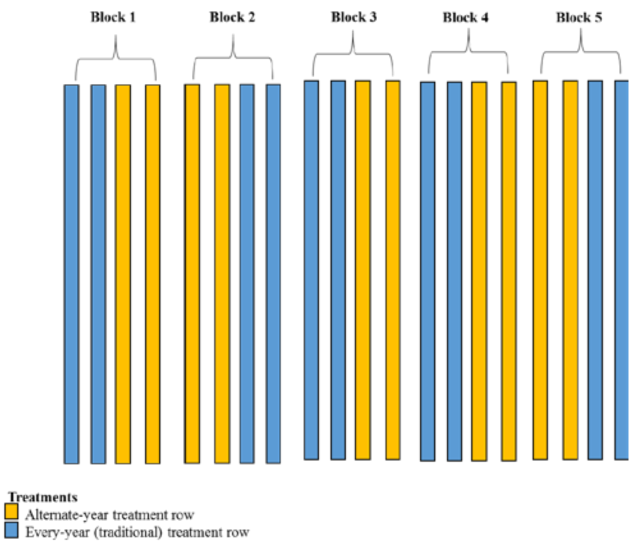

Figure 1. Experimental design comparing alternate- and every-year production systems in summer-bearing red raspberry. Two rows per experimental unit within a block are required for equipment operation.

Data collection will begin in 2015, in which a baseline enterprise budget will be developed through informal surveys of growers. These data will be used to update the raspberry production cost study completed by MacConnell and Kangiser (2007). This budget will be used as benchmark for assessing and estimating changes in net profit due to alternate production. Supplementary information, such as differences in number of pesticide and fertilizer applications between the two treatments, labor requirements, as well as yield and productivity, will be incorporated in these budgets. Plant growth and productivity will be measured from ten plants randomly selected within each treatment row. Cane numbers, height, and diameter will be measured to assess establishment and growth between the two treatments. Yield and average berry size will also be determined in order to assess how the treatments impact fruit production. Overall, these data will be utilized to evaluate the economic viability of alternate year-production.

Given the proposed objectives, this will be a long-term project that will collect harvest data from alternate year treatment plots for three cropping seasons. This translates into a six-year project, with alternate-year production occurring in 2016, 2018, and 2020, and years of strictly primocane production in 2017 and 2010. A table describing the timeline of the project is provided in **Table 1**.

Table 1. Timeline of crop production for project comparing alternate- and every-year production of red raspberry.

Treatments	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Alternate-year production	Establishment	First crop	No crop	Second crop	No crop	Third crop
Every-year production	Establishment	First crop	Second crop	Third crop	Fourth crop	Fifth crop

Anticipated Benefits and Information Transfer:

Completion of this project will provide growers relevant information about the potential cost savings of alternate-year production relative to traditional every-year production. This project will also provide baseline information about implementation of this system in summer-bearing red raspberry grown in Washington. Both information derived from the benefit-cost analysis and evaluations of plant growth and productivity will be shared at grower conferences and through two WSU Extension Publication (Fact Sheet and Excel Workbook). Results will also be available on the WSU Small Fruits Horticulture website (http://smallfruits.cahnrs. wsu.edu/) and be published in a peer-reviewed research publication.

References:

Barney, D.L. and C. Miles (eds.). 2007. Commercial Red Raspberry Production in the Pacific Northwest. PNW 598.

Bell, N., E. Nelson, B. Strik, and L. Martin. 1992. Assessment of winter injury to berry crops in Oregon, 1991. Oregon State University Agricultural Experiment Station, Special Report 902, July, 1992. 23 pp.

Bullock, R.M. 1963. Spacing and time of training blackberries. Oregon Hort. Soc. Proc. 55:59-60.

MacConnell, C. and M. Kangiser. 2007. Washington Machine Harvested Red Raspberry Cost of Production Study for Field Re-establishment. Washington State University Whatcom County Extension.

Martin, L.W. and E.H. Nelson. 1979. Establishment and management of 'Boysenberries' in Western Oregon. Oregon State University Agr. Expt. Sta. Circ. 677.

Pritts, M., 2009. Pruning Raspberries and Blackberries. New York Berry News. 8(4): 7 pp. Accessed 5 Nov. 2014 at: < http://www.fruit.cornell.edu/berry/production/pdfs/ raspruning.pdf>.

Strik, B. 1996. Blackberry Production in Oregon. 11th Annual Conference of the North American Bramble Growers Association. Accessed 5 Nov. 2014 at: < http:// berrygrape.org/blackberry-production-in-oregon/>.

Washington Red Raspberry Commission (WRRC). 2013. 2013 Pacific Northwest Raspberry Assessment Report. WWRC. Accessed Nov. 5 2014 at: <http://www.red-raspberry.org/>.

Budget and Justification:

	2015	2016	2017	2018	2019	2020
Salaries[1/]	$5,085	$2,648	$5,013	$5,214	$6,911	$10,282
Time-Slip[2/]	$1,200	$5,824	$6,057	$6,299	$6,551	$6,815
Operations (goods & services)[3/]	$125	$200	$50	$50	$50	$1,050
Travel[4/]	$915	$1,258	$493	$493	$493	$2,023
Meetings	$	$	$	$	$	$
Other	$	$	$	$	$	$
Equipment[4/]	$	$	$	$	$	$
Benefits[5/]	$1,636	$1,339	$2,343	$2,437	$2,960	$3,967
Total	**$8,958**	**$11,269**	**$13,956**	**$14,493**	**$16,965**	**$24,137**

[1/] Research Associate (co-PI) at the WSU School of Economic Sciences (8.33% FTE in Year 1; 4.17% FTE in Year 2; 2.08% FTE in Year 5; and 6.25% FTE in Year 6); Scientific assistant in Small Fruit Horticulture program at 10% FTE per year from 2017 to 2020.
[2/]Time-slip for treatment implementation and field data collection at $10/hr for 40 hours/wk for 3 wks in 2015 (establishment) and for 14 wks per year from 2016-2020, factoring in 4% inflation rate for WSU personnel.
[3/]General office supplies (Year 1); incentives to participants who will help develop and review the enterprise budgets (Year 2); field supplies (e.g, sample bags, flagging tape, etc.) for 2016 to 2020; journal publication charge (Year 6).
[4/] Research Associate will meet with growers in order to collect and validate data for the every-year raspberry enterprise budget (Year 1 and Year 2) and the alternate-year raspberry enterprise budget (Year 6). Research associate will also co-present with PI key results of the study at a grower conference in Year 6 (e.g., Washington Small Fruit Conference); travel for PI to commute from Mount Vernon, WA, to field site in Lynden, WA approximately 3 times in 2015 and ten times per year from 2016-2020 (88 mi/roundtrip at 0.56 cents/mi) .
[5/]No equipment funding requests.
[6/]Benefits are calculated at 29.8% of monthly salary for Research Associate; Benefits for non-student time slip is 9.8%; Benefits for Scientific Assistant is __35.43%_____.

2015 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

Project Title: Impacts of Alleyway Cover Crops on Soil Quality and Plant Competition in Established Red Raspberry

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PI: Mark Mazzola
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Co-PI: Chris Benedict
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Cooperators: Undisclosed.

Year Initiated 2015 **Current Year** 2015 **Terminating Year** 2016

Total Project Request: **Year 1** $8,157 **Year 2** $8,297

Other funding sources:
Agency Name: Northwestern Agricultural Research Foundation (NARF)
Amt. Requested/Awarded: $7,032
Notes: We will be seeking a 50% match for this proposal from NARF. With the total cost for the first year amounting to $15,189, this equates to $8,157 requested each from WRRC and $7,032 from NARF.

Description:
Red raspberry (*Rubus idaeus*) alleyway management in northwestern Washington typically consists of repeated cultivation and herbicide applications in order to maintain bare soil between rows. These management practices can have deleterious effects on soil quality. Raspberry plants and fruit quality may also be negatively impacted by these management practices. Some of the effects include increased soil compaction and erosion, reduced soil microbial diversity, and reduced photosynthetic activity and increased spider mite activity from excessive dust. An alternative management approach is planting alleyway cover crops, such as annual cover crops or perennial groundcovers. Studies on alleyway cover crops in raspberry production systems are

limited, especially in Washington. This project proposes to address this knowledge gap by measuring the effects of alleyway cover crops in established red raspberry on: 1) Soil quality, using select chemical, physical, and biological variables; 2) Soil microbial community structure, with specific focus on changes in pathogenic and pathogen-suppressing populations; and 3) Plant competition between alleyway cover crops and raspberry plants. Completion of this research will provide valuable information regarding the suitability of alleyway cover crops in raspberry production in northwest Washington.

Justification and Background:

Management of alleyways in raspberry fields in northwest Washington entails repeated cultivation and herbicide applications. While effective at minimizing weeds, this strategy has several disadvantages, including: 1) Reductions in soil quality, which can manifest into increased erosion, compaction, loss of physical structure, and reductions in nutrient- and water-holding capacity (Funt and Hall, 2013; PNW Extension, 2007); 2) Increased dust during the dry season, which can reduce plant productivity, as well as promote spider mite activity (PNW Extension, 2007); 3) Complicate operation of mechanical equipment because clean-cultivated fields tend to be difficult to operate in due to mud (Funt and Hall, 2013; PNW Extension, 2007); and 4) Increased expenditures due to associated mechanical, fuel, and labor costs of frequent alleyway management (PNW Extension, 2007).

One approach to reduce the negative impacts of current alleyway management strategies is through cover crops. Zebarth et al. (1993) observed that nitrogen cycling improved and nitrate leaching was reduced with cover crops in the alleyways of raspberries in Canada. Yet, a small reduction in berry yield was also observed. Bowen and Freyman (1995) observed no differences in yield with white clover (*Trifolium repens*) established in the alleyways compared to clean cultivation, but yield was significantly lower with perennial ryegrass (*Lolium perenne*) compared to clean cultivation. In another four-year study with alleyway cover crops in raspberry, plots that were annually seeded with oats (*Avena* spp.) produced the same yields as clean cultivated plots (Sanderson and Cutcliffe, 1988). Certain species of cover crops may also have the potential to suppress diseases and pests, which may be useful in fields starting to exhibit declines in plant health. Mustard crops are commonly used as green manures or biofumigants in Washington to control nematodes and other soilborne diseases (Clark, 2012). Specific wheat cultivars can induce soilborne disease suppression by enhancing antagonistic microbial populations (Mazzola and Gu, 2002). Cover crops can also suppress weeds, which negatively impact crop production and can serve as nematode hosts (Funt and Hall, 2013; Forge et al., 2000).

Previous research demonstrates that there are many potential benefits of cover crops in perennial fruit systems. The role of cover crops in promoting soil quality and suppressing diseases/pests have been minimally studied in raspberry, particularly in Washington. Ensuring the continued productivity of this industry through improved soil and plant management strategies, such as through the successful use of cover crops, will help ensure the economic vitality of this industry.

Relationship to WRRC Research Priority(s):

This project addresses the following objectives: 1) Understanding soil ecology and soil borne pathogens and their effects on plant health and crop yields and 2) Soil fumigation techniques and *alternatives* to control soil pathogens, nematodes, and weeds.

Objectives:
The primary objectives of this experiment are to measure the effects of alleyway cover crops in established red raspberry on: 1) Soil quality, using select chemical, physical, and biological variables; 2) Soil microbial community structure, with specific focus on changes in pathogenic and pathogen-suppressing populations; and 3) Plant competition between alleyway cover crops and raspberry plants. An additional goal is to evaluate the suitability of select annual and perennial grains and turfgrasses as alleyway cover crops in raspberry production in northwest Washington.

Procedures:
Cover crops were seeded in an established commercial field of 'Meeker' located in Lynden, WA, on October 1, 2014. The site was reportedly starting to decline due to soilborne pathogens/pests and the investigators identified the site as suitable for an observational cover crop study that could become a more comprehensive study with project support. Cover crop treatments were established as a completely randomized design with an experimental unit representing a 30 x 12 ft plot, replicated four times per treatment. Plots span the entire alleyway on both sides of the row and a minimum of 60 ft were maintained between plots as buffer. Treatment cover crops seeded in the alleyways include: 1) Hard, red winter wheat cv. Norwest 553 (*Triticum aestivum*); 2) Soft, white winter wheat cv. Rosalyn (*T. aestivum*); 3) Winter-hardy oats cv. TAM 606 (*Avena sativa*); 4) Winter-hardy oats cv. Nora (*A. sativa*); 5) Ryegrass (*Lolium* spp.) mix that included 51.25% intermediate ryegrass cv. Tetralite and 48.24% tetraploid perennial ryegrass cv. Kentaur ; 6) Perennial ryegrass (*L. perenne*) mix that included 43.93% 'Esquire', 31.44% 'TopHat 2', and 22.49% 'Tetragreen'; 7) Triticale cv. Trical 103BB (*Triticosecale* sp.); 8) Triticale cv. TriMark 099 (*Triticosecale* sp.); and 9) a generic cereal rye (*Secale cereale*). All cover crops were seeded at recommended rates. Untreated bare soil controls were also maintained, which represents conventional management of raspberry alleyways.

Fall 2014 soil samples were collected within rows prior to seeding and will provide baseline soil biological (microbial), physical, and chemical information. Cover crop growth will be monitored every 2-4 weeks through fall and winter. In early spring of 2015, cover crops will be mowed down. When necessary, perennial cover crops will be mowed to a height of 4-6 in throughout the season. Bare soil areas will be clean-cultivated and managed per industry standard. Soil and plant growth variables will be collected according to **Table 1**.

Table 1. Variables and timeline of sample collection for alley cover crop in red raspberry experiment.

Variable	Fall 2014	Spring 2015	Summer 2015	Fall 2015	Spring 2016	Summer 2016	Fall 2016
Soils[z]							
Bulk density		X		X	X		X
Aggregate stability		X		X	X		X
Infiltration		X		X	X		X
Nutrients (macro, micro, & organic matter)	X	X		X	X		X
Soil microbiology[y]	X	X		X	X		X
Raspberry plants							
Yield			X			X	
Cane diameter & density			X			X	

[z]Samples will be collected and analyzed separately in alleyways and rows; bulk density, aggregate stability, and infiltration will

only be monitored in alleyways; all other soil variables will be analyzed both in row and alleyway samples.
[y]Soil microbial populations will be monitored using Terminal Restriction Fragment Length Polymorphisms (T-RFLP).

Anticipated Benefits and Information Transfer:

Compatibility of alleyway cover cropping in raspberry may translate into adoption and subsequent improvements in soil quality. Improvements in biological aspects of soil quality may help mitigate soilborne diseases/pests. Benefits may also translate into financial savings on behalf of growers by reducing costs associated with conventional management of alleyways (i.e., frequent cultivation and herbicides). Results of this project will be part of a doctoral thesis, published in a peer-reviewed journal, and presented in a WSU Extension Publication. Furthermore, final results will be presented at the Washington Small Fruit Conference in Lynden and shared online at the Small Fruits Website (http://smallfruits.cahnrs.wsu.edu/).

References:

Bowen, P. and S. Freyman. 1995. Ground covers affect raspberry yield, photosynthesis, and nitrogen nutrition of primocanes. HortScience 30(2):238-241.

Clark, A. 2012. Managing cover crops profitably. 3rd ed. SARE, College Park, MD.

Forge, T.A., R.E Ingham, D. Kaufman, and J.N. Pinkerton. 2000. Population growth of *Pratylenchus penetrans* on winter cover crops grown in the Pacific Northwest. J. Nematol. 32(1):42-51.

Funt, R.C. and H.K. Hall. 2013. Raspberries. CAB International, Oxfordshire, UK.

Mazzola, M. and Y. Gu. 2002. Wheat genotype-specific induction of soil microbial communities suppressive to disease incited by Rhizoctonia solani Anastomosis Group (AG)-5 and AG-8. Phytopathology 92(12):1300-1307.

Pacific Northwest Extension. 2007. Commercial red raspberry production in the Pacific Northwest. PNW 598.

Sanderson, K.R. and J.A. Cutcliffe. 1988. Effect of inter-row soil management on growth and yield of red raspberry. Can. J. Plant Sci. 68:283-285.

Washington Red Raspberry Commission (WRRC). 2013. 2013 Production Statistics. Accessed on 8 Oct. 2014 at: http://www.red-raspberry.org/statistics.asp.

Zebarth, B.J., S. Freyman, and C.G. Kowalenko. 1993. Effect of ground covers and tillage between raspberry rows on selected soil physical and chemical parameters and crop response. Can. J. Soil Sci. 73:481-488.

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

	2015	**2016**
Salaries[1/]	$	$
Time-Slip[2/]	$3,200	$3,328
Operations (goods & services)[3/]	$4,150	$4,150
Travel[4/]	$493	$493
Meetings	$	$
Other	$	$
Equipment[5/]	$	$
Benefits[6/]	$314	$326
Total	**$8,157**	**$8,297**

Budget Justification

[2/]Time-slip for two months of graduate student summer work at $10/hr in 2015 & $10.40/hr in 2016.
[3/]Funds for soil quality evaluations, including chemical and biological analyses, which will cover cost of reagents, soil DNA isolation kits, primers, gels, sequencing, etc. (disposables).; figures based on 360 total samples (including running T-RFLP samples in triplicate) from fall 2014, spring 2015, fall 2015, and spring 2016 with an estimated $23 per sample for both chemical and biological analyses; amount also includes cost of cover crop seeds for treatments.
[4/]Travel funds for commuting from Mount Vernon, WA, to field site in Lynden, WA approximately ten

times in 2015 and 2016 (88 mi/roundtrip at 0.56 cents/mi).
[6/]Benefits for a part-time student is 9.8%.

Washington Red Raspberry Commission
Progress Report for 2014 Projects

Project No:
Title: Mechanizing red raspberry pruning and cane tying
Personnel: Manoj Karkee; Julie Tarara
Reporting Period: Nov 2013 – Oct 2014

Accomplishments:
In 2014, a new planting of raspberries was established in Prosser. The plot is 0.4 acre, rows 10' apart, plants spaced 2.5' apart, with additional space between plots to keep the cultivars from growing into each other. Three cultivars were included: Chemainus, Meeker, and Wakefield. There were total of 300 plants, 100 of each cultivar. The plot is set up in a randomized complete block, with four replications for statistical validity. The trellis is identical to the commercial standard. The plants are drip irrigated. Weed control was achieved by a combination of herbicide, mowing, and hand weeding. The smaller plot planted in 2013 was continued be managed, and produced fruit. We applied a spray to control SWD in the 2013 plot. There had been some winter injury in the top third of the canes, but with no particular pattern. Primocane growth was adequate. The plot will be pruned and tied after leaf fall. After considering the growth pattern of primocanes and floricanes in our plot and the size of a smaller clip for the lower wire, we decided that the canes would be too compressed and the canopy too dense. Thus we did not further pursue the proposed training system for physically separating primocane and floricanes.

In 2014, three different conceptual designs for cane bundling mechanism were evaluated. First, the concepts were modeled in a 3D software and then simple prototypes were built. One of the concepts was than developed to a field scale prototype. This prototype uses clawing mechanism to collect primocanes within a defined space and bring them together to form a bundle (Fig. 1 - Right). The mechanism has degrees of freedom to move in-and-out and up-and-down in the plant canopy. The prototype is mounted on a 3-point hitch and is powered by tractor hydraulics for field operation. The prototype was evaluated in the lab for its functionality and speed.

Results:
Cane growth in the 2013 plot was shorter than expected, but the plants did fill the allotted space (Fig.1, Left). There was some residual winter damage but with no particular pattern. We did not achieve 100% 'take' in the 2014 plot, which we will remedy by replanting the missing spots in 2015. The 2014 plants showed strong cane growth overall (Fig. 1, center). A field scale prototype developed for cane bundling (Fig. 1, Right) was tested for its functionality in the lab and worked as expected. A cane tying mechanism is being added on top of the bundling mechanism. The prototype is expected to be ready for first field evaluation in early 2015.

Fig. 1: Left - a raspberry plot planted in spring 2013; Center – plants in the spring 2014 plot; and Right - a field scale prototype for cane bundling mechanism.

Publications: N/A

2014 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

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

Project Title: Mechanizing red raspberry pruning and cane tying

PI: Manoj Karkee
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Title: Assistant Professor
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Address 2:
City/State/Zip: Prosser, WA 99350

Co-PI: Julie Tarara
Organization: USDA-ARS
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Phone: 509-786-9392
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City/State/Zip: Prosser, WA 99350

Cooperators: Qin Zhang, WSU-CPAAS; Tom Walters, Walters Ag Research

Year Initiated 2014 Current Year 2015 Terminating Year 2016

Total Project Request: Year 1 $72,007 Year 2 $63,731 Year 3 $64,188

Other funding sources: For Year 2, $53,731 was requested as a sub-contract to WSU from the funding that WRRC and WSU scientists received through the WA Specialty Crop Block Grant program. An additional $10,000 is requested from WRRC to complement engineering research activities under this grant. In-kind supports of $2,500 from WRRC and $24,225 from WSU have been provided to the project. In addition, Maberry Packing and Enfield Farms have respectively offered $18,167 and $15,833 of in-kind support to this project. Similar funding and matching support is available for Year 3 of this project.

Description:
Cane management in red raspberry production is highly labor intensive. Labor availability is uncertain at best and labor cost is increasing. Currently, Washington growers estimate the pruning and tying cost in red-raspberry production to be from $500 to $800 per acre. In addition, labor is at risk for chronic and acute injury. Mechanization has the potential to substantially reduce labor use from cane management. In this project, we plan to develop a systematic approach for cane management through horticultural modifications and engineering solutions. A horticultural study will be conducted with three different types of red raspberries in eastern WA for their feasibility in mechanized pruning of two-year old canes. In addition, techniques will be developed to bundle one-year old canes together and tie them to the trellis wires. We expect that the successful completion of the proposed approach will lead to a practical cane management system. In the long term, commercial adoption of the system will improve economic sustainability of WA red raspberry production. The system will also have potential to be adapted to other WA specialty crops such as black raspberry and blackberry.

Justification and Background:
Red raspberry is a premium crop for WA, which produces more than 85% of total US production of frozen red raspberries. This is a bi-annual crop where two-year old canes (floricanes) must be pruned out selectively every year without damaging one-year old canes (primocanes) (Fig. 1). Following pruning, a number of primocanes must be bundled and trained to trellis wires. This operation is highly labor intensive, costing about $500 - $800 per acre per year. Because labor

availability is increasingly uncertain and labor costs are continually increasing (Fennimore and Doohan, 2008), an automated or mechanized solution for pruning and training is a critically important need for the WA red raspberry industry. With immigration from Mexico to the USA expected to be net negative within the next five years (Pew Research Center, 2012) and Congressional reform of immigration law uncertain, it is expected that labor may soon become a critical constraint on red raspberry production. Therefore, it is crucial that we begin now to develop mechanization technologies so that the technology is ready for industry adoption before its competitiveness and sustainability may be compromised. During this project we will systematically evaluate horticultural and engineering solutions to cane training and pruning. Our goal is to develop viable, practical techniques of performing training and pruning that reduce labor from its current requirements and consequently reduce the cost of production while minimizing crop loss.

Fig. 1: Red-raspberry pruning and tying

"Labor shortage, quality of available labor, need for labor training and cost associated with all of this are the biggest issues we are [currently] facing in raspberry production." – A WA Grower, Feb, 2012.

This project will impact all red raspberry growers in WA who use the floricane production system - the entire industry relies on manual labor to prune and tie canes. This combined operation represents about 35% of the total variable costs of production (MacConnell and Kansiger, 2007). The project is expected to generate industry-applicable horticultural and engineering techniques to improve labor productivity and reduce labor demand. Success in this project will dramatically reduce labor demand and costs, amounting to as much as $500 per acre per year for combined pruning and cane tying. These savings will lead to millions of dollars of economic benefit to WA red raspberry industry, which will substantially improve the competitiveness and long-term sustainability of the industry.

Relationship to WRRC Research Priority(s): This project directly addresses priority #2: "Labor saving cultural practices including mechanical pruning and tying techniques." By evaluating current major varieties in eastern Washington, it also contributes to the commission's #1 priority of cultivar development.

Objectives to be accomplished in 2015:

The primary goal of the proposed work is to minimize labor demand in red raspberry pruning through integrated horticultural and mechanization, or automation solutions. To achieve the overall goal, we will particularly focus on the following objectives over the three year duration of this project.

1. Establish at Washington State University's Center for Precision Agricultural and Automation Systems (WSU-CPAAS) a block of red raspberries that will include three commercial cultivars;
2. Develop and evaluate mechanization technologies for cane management, which will include
    a. Bundling and tying mechanisms for the primocanes that will bear the following year's crop, and
    b. Sensing systems for floricane identification and a floricane pruning mechanism

Please refer to the progress report submitted along with this funding proposal for the accomplishments made in 2014. Particularly in the Year 2015, progress will be made in the following research activities.

1. Continue to manage the raspberry plot in Prosser, WA
2. Continue the development of prototype cane bundling and tying machine
3. Evaluate and improve in the lab
4. Outreach activities

Procedures:

Objective #1 - Horticultural Management of Red Raspberry Plot (Lead –Tarara): All cultural practices will be according to commercial standards. The following horticultural attributes will be measured: number of canes per plant; cane length at harvest; number of canes damaged by the bundler (evaluated via necrosis); number of fruiting laterals per sample cane; yield; and weight of dormant-pruned spent floricanes.

Objective #2 - Engineering Approaches (Lead – Karkee): We will complete the designing of cane bundling and tying technologies in year 2 (2015). We will also complete the development of a prototype machine with a pair of augers to move primocanes to a vertical position and bring them together, and a clamping mechanism to tie the canes together. The prototype will be evaluated in the lab and in the field. This year, we will also investigate a method to identify and locate floricanes for pruning. A color vision camera and a laser scanner will be used to identify and locate floricanes for pruning. An over-the-row tunnel system (already developed by PI Karkee and available to this project) will be used to reduce the effect of variable lighting conditions during imaging. We will investigate the use of food-grade red paint as well as red string-tying to provide the additional information for the image processing system.

Anticipated Benefits and Information Transfer:

This project will evaluate new training systems with the potential to facilitate development of mechanized approaches to both training and pruning, which will ultimately reduce the estimated $500-$800 per acre cost of these practices. Working connections among growers, horticulturists, and engineers will be fostered by this well-defined project. Following this, we expect smooth and effective cooperation among parties on future mechanization projects. Results will be transferred to users at the planned workshops and at annual berry meetings, including the Washington Small Fruit Conference. The direct participation of growers in this project will also facilitate transfer to growers through peer-to-peer connections.

References:

Fennimore, S. A., and D. J. Doohan, 2008. The Challenges of Specialty Crop Weed Control, Future Directions. Weed Technology, 22: 364-372.

MacConnell, C., and M. Kangiser. 2007. Washington Machine Harvested Red Raspberry Cost of Production Study for Field Re-establishment. Washington State University, Whatcom County Extension.

Pew Research Center. 2012. Net Migration from Mexico Falls to Zero—and Perhaps Less. Available at: http://www.pewhispanic.org/files/2012/04/Mexican-migrants-report_final.pdf; assessed on: accessed 6 Nov, 2013.

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

	2014	2015	2016
Salaries	$23,993	$23,993	$23,993
Time-Slip	$1,080	$3,160	$3,608
Operations (goods & services)	$22,383	$9,482	$8,038
Travel	$3,048	$3,048	$3,048
Other/Miscellaneous	$1,370	$1,370	$1,369
Benefits	$20,133	$22,678	$24,132
Total	**$72,007**	**$63,731**	**$64,188**

Budget Justification

Salaries (Sub-Total: $71,979) – All values are in accordance with Washington State University's mandated rates for salaries, wages, and salary inflation. A salary of $14,294 per annum (Year 1 rate), is requested to hire a graduate student (under Dr. Karkee's supervision) to work on the day-to-day research activities in developing algorithms and prototype machines and conducting field tests in red raspberry bundling and tying. Partial support for another graduate student will be provided at $5,473 per year. This graduate student will be responsible for carrying out sensing and pruning mechanism development tasks. In addition, a salary of $4,226 (5% of his full time appointment) per year (Year 1 rate) is requested for Co-PI Karkee, who will direct the design, planning, and implementation of engineering research activities. Dr. Karkee will provide an additional 11.25% or more of his time to this project as matching support.

Wages (Sub-Total: $7,848) – Wages are required for installation and maintenance of, and data collection in the field plot at the hourly rates of $12.00 for field labor. Total estimated wages are $1,080 for Yr1, $3,160 for Yr2, and $3,608 for Yr3.

Supplies (Sub-Total: $39,903) – Engineering materials and supplies are estimated at $34,503 for the duration of the project. The budget will cover the cost of materials and supplies for horticultural studies as well as engineering prototype development. The bulk of horticultural goods and services were required for year 1--field establishment and maintenance ($13,483). These included contract fumigation service, a drip irrigation system, trellis materials, plants, standard fertilizers and agri-chemicals, and land use charges. Also included were WSU-Prosser's crop maintenance service fees for land preparation, planting, installing the irrigation system, applying irrigation, and applying pesticides and herbicides as needed. In years 2 and 3 ($4,982 and $5,038), materials and services include WSU-Prosser's crop maintenance service fees, necessary chemicals and fertilizers, trellis and irrigation repairs, land charges, and field supplies for collecting horticultural data (including picking bins, field notebooks, and measuring tapes and counters). For the materials and supplies (including aluminum sections, iron sections, nuts, and bolts) for engineering prototype development, a budget of $3,500, $4,500 and $3,000 is requested respectively for year 1, year 2 and year 3. In-house fabrication and technician support is available to PI Karkee to build research prototypes, which has reduced the requested budgeted for prototype development. Finally, irrigation supplies of $5,400 incurred in Year 1 only to equip the drip irrigation system with the required sand filter.

Travel (Sub-Total: $9,144) – Each year, one graduate student will travel to Lynden, WA to conduct field experiments in collaboration with grower collaborators. At the standard per diem rate, this travel will cost $988 each year (mileage – 574 miles @ $0.57 = $327; lodging – 5 night @ $77 = $385; and meals – 6 days @ $46 = $276). Two-day long trips to the data collection site are also included for PI Karkee and Co-PI Tarara each year to supervise the field experiment as well as attend the project annual meeting, which will cost $619 each person-trip (Mileage = $327, Lodging = $154, and Meals = 138). In addition, travel funds are requested for Students, PI Karkee, and Co-PI Tarara to attend professional conferences during three years of this project. Total travel cost will be $3,048 per year.

Other (Sub-Total: $4,109): A miscellaneous budget of $1,370 per year is requested to cover unexpected minor expenses during the project duration.

Benefits (Sub-Total: $66,943) – All values are in accordance with Washington State University's mandated rates for benefits and benefit inflation according to staff classification: $13,582 per annum for one graduate student (Year 1 rate); $4,527 per annum for partial support to a second graduate student (Year 1), $1,251 for PI Karkee (Year 1 rate); and $8.64/hour for field labor. Total estimated benefits costs are $20,133 for Yr1, $22,678 for Yr2, and $24,132 for Yr3.

Current & Pending Support-Karkee

NAME (List/PD #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
ACTIVE					
Slaughter (PD), Karkee, Zhang et al.	USDA Specialty Crop Research Initiative	$2,175,901	10/14 to 09/18	5%	Crop Signaling for Automated Weed/Crop Differentiation and Mechanized Weed Control in Vegetable Crops
Karkee, M. (PI), J. Leachman, M. Taylor, Q. Zhang	WA Blueberry Commission	$19,543	01/14 to 12/2015	5%	Unmanned Aerial Systems (UASs) for Mitigating Bird Damage in Blueberry Crops: Proof of Concept
Hashimoto (PD), Chiang; Cooper; Eggeman; Karkee; Vaugh; Yanagida; Zhang; etc.	USDA-NIFA-BRDI	$6,000,000	04/12 to 03/16	15%	Conversion of High-Yield Tropical Biomass into Sustainable Biofuels
Bierlink (PD), Karkee (WSU-PD); Tarara	WSDA Special Crop Block Grant/WRRC	$199,926	01/14 to 12/16	16%	Mechanizing Red Raspberry Pruning and Tying
Karkee (PI) ; Lewis ; Mo; Zhang	National Robotics Initiative - NSF and USDA-NIFA	$548,735	10/13 to 09/16	15%	Human machine collaboration for automated harvesting of tree fruit
PENDING					
Karkee (PD); Zhang; Whiting	Agricultural and Food Research Initiative-USDA-NIFA	$499,302	10/14 to 09/17	10%	Shake and Catch Harvesting for Fresh Market Apples
Karkee	National Science Foundation	$501,065	01/15 to 12/19	10%	Integration of Research and Education for Automated Pruning of Perennial Fruit Trees and for Developing Human Resources for Automated and Robotic Agriculture

Current & Pending Support-Tarara

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
Hirst et al.	Current: NIFA-SCRI	$3,027,747	9/1/12 to 8/31/16	20%	Automation of dormant pruning of specialty crops
Bierlink (PD), Karkee (WSU-PD); Tarara	Pending: WSDA Special Crop Block Grant/WRRC	$199,926	10/13 to 09/16	15%	Mechanizing Red Raspberry Pruning and Tying

Agriculture Development Group, Inc.

2014 Raspberry Field Program – 9 Treatments

Trial ID: Rasp.Botrytis.9trt.2014 Protocol ID: Rasp.Botrytis.9trt.2014
Location: Whatcom Co Study Director: Tom Walters
Project ID: 2014 Investigator: Alan Schreiber
Sponsor Contact:

General Trial Information

Study Director: Tom Walters **Title:** Ag Researcher
Investigator: Alan Schreiber **Title:** President

Discipline: F fungicide
Trial Reliability: GOOD
Initiation Date: Apr-15-2014 **Planned Completion Date:** Oct-15-2014

Trial Location

City: Everson
State/Prov.: Washington
Postal Code: 98247
Country: USA United States
Directions:

This trial is located on the Samson Farms property, at the corner of Noon Road and Vandyke Rd, near Everson, WA.

Keywords: fungicide, efficacy, botrytis, raspberries

Objectives:

To test the efficacy of various fungicides for control of fungicidal resistant botrytis in raspberry.

Agriculture Development Group, Inc.

Personnel

Study Director: Tom Walters **Title:** Ag Researcher
Affiliation: Walters Ag Research
Address: 2117 Meadows Lane
Location: Anacortes Washington
Postal Code: 98221 **E-mail:** waltersagresearch@frontier.com
Phone No.: 360-420-2776
Investigator: Alan Schreiber **Title:** President
Affiliation: Agriculture Development Group, Inc.
Address: 2621 Ringold Road
Location: Eltopia, WA
Postal Code: 99330 **E-mail:** aschreib@centurytel.net
Phone No.: 509-266-4348 **Mobile No.:** 509-539-4537

Crop Description

Crop 1: RUBID Rubus idaeus Red raspberry
Variety: Meeker
BBCH Scale: BPER
Planting Method: ESTABL established

Pest Description

Pest 1 Type: D **Code:** BOTRSP Botrytis sp.
Common Name: Botrytis sp.
Description: Botrytis of Raspberries

Site and Design

Plot Width, Unit: 10 FT **Site Type:** FIELD field
Plot Length, Unit: 30 FT **Experimental Unit:** 1 PLOT plot
Plot Area, Unit: 300 FT2 **Tillage Type:** NOTILL no-till
Replications: 4 **Study Design:** RACOBL Randomized Complete Block (RCB)
Untreated Arrangement: INCLUDED single control randomized in each block

Agriculture Development Group, Inc.

Application Description

	A	B	C	D	E	F
Application Date:	May-27-2014	Jun-5-2014	Jun-16-2014	Jun-24-2014	Jul-2-2014	Jul-11-2014
Time of Day:	7am	8am	10am	7am	9am	8am
Application Method:	SPRAY	SPRAY	SPRAY	SPRAY	SPRAY	SPRAY
Application Timing:	7 Day Interval	7 Day Interval	7 Day Interval	7 Day Interval	7 Day Interval	7 Day Interval
Application Placement:	FOLIAR	FOLIAR	FOLIAR	FOLIAR	FOLIAR	FOLIAR
Applied By:	Tom Walters	Tom Walters	Tom Walters	Tom Walters	Tom Walters	Tom Walters
Air Temperature, Unit:	55 F	62 F	60 F	64 F	72 F	68 F
Wind Velocity, Unit:	0 MPH	0 MPH	2 MPH	2 MPH	3 MPH	0 MPH
Wind Direction:			W	SW	NW	

Crop Stage At Each Application

	A	B	C	D	E	F
Crop 1 Code, BBCH Scale:	RUBID BPER	RUBID BPER	RUBID BPER	RUBID BPER	RUBID BPER	RUBID BPER

Pest Stage At Each Application

	A	B	C	D	E	F
Pest 1 Code, Type, Scale:	BOTRSP D	BOTRSP D	BOTRSP D	BOTRSP D	BOTRSP D	BOTRSP D

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Application Equipment						
	A	**B**	**C**	**D**	**E**	**F**
Appl. Equipment:	Over Row Boom	Over Row Boom	Over Row Boom	Over Row Boom	Over Row Boom	Over Row Boom
Equipment Type:	SPRAYR	SPRAYR	SPRAYR	SPRAYR	SPRAYR	SPRAYR
Operation Pressure, Unit:	225 psi	225 psi	225 psi	300 psi	300 psi	300 psi
Nozzle Type:	Tee-Jet	Tee-Jet	Tee-Jet	Tee-Jet	Tee-Jet	Tee-Jet
Nozzle Size:	D-3	D-3	D-3	D-3	D-3	D-3
Nozzle Spacing, Unit:	12 in	12 in	12 in	12 in	12 in	12 in
Nozzles/Row:	12	12	12	12	12	12
Band Width, Unit:	6 ft	6 ft	6 ft	6 ft	6 ft	6 ft
Boom Length, Unit:	6 FT	6 FT	6 FT	6 FT	6 FT	6 FT
Ground Speed, Unit:	2.5 mph	2.5 mph	2.5 mph	2.5 mph	2.5 mph	2.5 mph
Carrier:	WATER	WATER	WATER	WATER	WATER	WATER
Spray Volume, Unit:	100 gal/ac	100 gal/ac	100 gal/ac	100 gal/ac	100 gal/ac	100 gal/ac
Mix Size, Unit:	13 liters	13 liters	13 liters	13 liters	13 liters	13 liters

Agriculture Development Group, Inc.

2014 Raspberry Field Program – 9 Treatment

Trial ID: Rasp.Botrytis.9trt.2014 Protocol ID: Rasp.Botrytis.9trt.2014
Location: Whatcom Co Study Director: Tom Walters
Project ID: 2014 Investigator: Alan Schreiber
Sponsor Contact:

Reps: 4 Plots: 10 by 30 feet
Spray vol: 100 gal/ac Mix size: 12.55 liters (min 12.514)

Trt No.	Treatment Name	Form Conc	Form Type	Description	Rate	Rate Unit	Appl Code	Amt Product to Measure	Rep 1	2	3	4
1	Untreated Check			not treated					101	207	302	407
2	CAPTAN	80	WG		2	lb/a	A	24.99 g/4 pl	102	209	304	402
	SWITCH	62.5	WG		14	oz/a	A	10.93 g/4 pl				
	CAPTAN	80	WG		2	lb/a	B	24.99 g/4 pl				
	PRISTINE	38	WG		23	oz/a	B	17.96 g/4 pl				
	CAPTAN	80	WG		2	lb/a	C	24.99 g/4 pl				
	CAPTAN	80	WG		2	lb/a	D	24.99 g/4 pl				
	SWITCH	62.5	WG		14	oz/a	D	10.93 g/4 pl				
	CAPTAN	80	WG		2	lb/a	E	24.99 g/4 pl				
	Rovral	41.6	F		2	pt/a	E	26.07 ml/4 pl				
	CAPTAN	80	WG		2	lb/a	F	24.99 g/4 pl				
	SWITCH	62.5	WG		14	oz/a	F	10.93 g/4 pl				
3	CAPTAN	80	WG		2.5	lb/a	A	31.24 g/4 pl	103	202	305	404
	SWITCH	62.5	WG		14	oz/a	A	10.93 g/4 pl				
	CAPTAN	80	WG		2.5	lb/a	B	31.24 g/4 pl				
	PRISTINE	38	WG		23	oz/a	B	17.96 g/4 pl				
	CAPTAN	80	WG		2.5	lb/a	C	31.24 g/4 pl				
	CAPTAN	80	WG		2.5	lb/a	D	31.24 g/4 pl				
	SWITCH	62.5	WG		14	oz/a	D	10.93 g/4 pl				
	CAPTAN	80	WG		2.5	lb/a	E	31.24 g/4 pl				
	Rovral	41.6	F		2	pt/a	E	26.07 ml/4 pl				
	SWITCH	62.5	WG		14	oz/a	F	10.93 g/4 pl				
4	CAPTAN	80	WG		2.5	lb/a	A	31.24 g/4 pl	104	206	301	403
	CAPTAN	80	WG		2.5	lb/a	B	31.24 g/4 pl				
	CAPTAN	80	WG		2.5	lb/a	C	31.24 g/4 pl				
	SWITCH	62.5	WG		14	oz/a	C	10.93 g/4 pl				
	CAPTAN	80	WG		2.5	lb/a	D	31.24 g/4 pl				
	SWITCH	62.5	WG		14	oz/a	D	10.93 g/4 pl				

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Reps: 4 Plots: 10 by 30 feet
Spray vol: 100 gal/ac Mix size: 12.55 liters (min 12.514)

Trt No.	Treatment Name	Form Conc	Form Type	Description	Rate	Rate Unit	Appl Code	Amt Product to Measure	Rep 1	2	3	4
5	CAPTAN	80	WG		2.5	lb/a	A	31.24 g/4 pl	105	203	308	409
	SWITCH	62.5	WG		14	oz/a	A	10.93 g/4 pl				
	CAPTAN	80	WG		2.5	lb/a	B	31.24 g/4 pl				
	CAPTAN	80	WG		2.5	lb/a	C	31.24 g/4 pl				
	CAPTAN	80	WG		2.5	lb/a	D	31.24 g/4 pl				
	SWITCH	62.5	WG		14	oz/a	D	10.93 g/4 pl				
6	CAPTAN	80	WG		1.5	lb/a	A	18.74 g/4 pl	106	204	307	406
	CAPTAN	80	WG		1.5	lb/a	B	18.74 g/4 pl				
	CAPTAN	80	WG		1.5	lb/a	C	18.74 g/4 pl				
	CAPTAN	80	WG		1.5	lb/a	D	18.74 g/4 pl				
	SWITCH	62.5	WG		14	oz/a	D	10.93 g/4 pl				
7	CAPTAN	80	WG		1.25	lb/a	A	15.62 g/4 pl	107	208	309	408
	SWITCH	62.5	WG		14	oz/a	A	10.93 g/4 pl				
	CAPTAN	80	WG		1.25	lb/a	B	15.62 g/4 pl				
	PRISTINE	38	WG		23	oz/a	B	17.96 g/4 pl				
	CAPTAN	80	WG		2.5	lb/a	C	31.24 g/4 pl				
	CAPTAN	80	WG		1.25	lb/a	D	15.62 g/4 pl				
	PRISTINE	38	WG		23	oz/a	D	17.96 g/4 pl				
	CAPTAN	80	WG		1.25	lb/a	E	15.62 g/4 pl				
	Rovral	41.6	F		2	pt/a	E	26.07 ml/4 pl				
	CAPTAN	80	WG		1.25	lb/a	F	15.62 g/4 pl				
	SWITCH	62.5	WG		14	oz/a	F	10.93 g/4 pl				
8	CAPTAN	80	WG		2	lb/a	A	24.99 g/4 pl	108	201	303	401
	SWITCH	62.5	WG		11.2	oz/a	A	8.747 g/4 pl				
	CAPTAN	80	WG		2	lb/a	B	24.99 g/4 pl				
	PRISTINE	38	WG		20	oz/a	B	15.62 g/4 pl				
	CAPTAN	80	WG		2.5	lb/a	C	31.24 g/4 pl				
	CAPTAN	80	WG		2	lb/a	D	24.99 g/4 pl				
	SWITCH	62.5	WG		11.2	oz/a	D	8.747 g/4 pl				
	CAPTAN	80	WG		2	lb/a	E	24.99 g/4 pl				
	Rovral	41.6	F		1	pt/a	E	13.03 ml/4 pl				
	CAPTAN	80	WG		2	lb/a	F	24.99 g/4 pl				
	SWITCH	62.5	WG		11.2	oz/a	F	8.747 g/4 pl				

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Reps: 4 Plots: 10 by 30 feet
Spray vol: 100 gal/ac Mix size: 12.55 liters (min 12.514)

Trt No.	Treatment Name	Form Conc	Form Type	Description	Rate	Rate Unit	Appl Code	Amt Product to Measure	Rep 1	2	3	4
9	CAPTAN	80	WG		2	lb/a	A	24.99 g/4 pl	109	205	306	405
	SWITCH	62.5	WG		14	oz/a	A	10.93 g/4 pl				
	CAPTAN	80	WG		2	lb/a	B	24.99 g/4 pl				
	PRISTINE	38	WG		23	oz/a	B	17.96 g/4 pl				
	CAPTAN	80	WG		2.5	lb/a	C	31.24 g/4 pl				
	CAPTAN	80	WG		2	lb/a	D	24.99 g/4 pl				
	SWITCH	62.5	WG		14	oz/a	D	10.93 g/4 pl				
	PhD	11.3	WG		6.2	oz/a	E	4.842 g/4 pl				
	Rovral	41.6	F		2	pt/a	E	26.07 ml/4 pl				
	PhD	11.3	WG		6.2	oz/a	F	4.842 g/4 pl				
	SWITCH	62.5	WG		14	oz/a	F	10.93 g/4 pl				

Sort Order: Replicate 1

Agriculture Development Group, Inc.

2014 Raspberry Field Program – 9 Treatment

Trial ID: Rasp.Botrytis.9trt.2014 Protocol ID: Rasp.Botrytis.9trt.2014
Location: Whatcom Co Study Director: Tom Walters
Project ID: 2014 Investigator: Alan Schreiber
Sponsor Contact:

Product quantities required for listed treatments and applications of trials included in this table:

Amount*	Unit	Treatment Name	Form Conc	Form Type	Lot Code
1,103.049	g	CAPTAN	80	WG	
221.298	g	SWITCH	62.5	WG	
115.975	g	PRISTINE	38	WG	
129.034	ml	Rovral	41.6	F	
10.653	g	PhD	11.3	WG	

* 'Per area' calculations based on 4 replicates of 10 by 30 feet 'Plot' experimental units (area of one treatment).
* 'Per area' calculations based on spray volume= 100 gal/ac, mix size= 12.55 liters (mix size basis).
* Product amount calculations increased 10 % for overage adjustment.

Agriculture Development Group, Inc.

2014 Raspberry Field Program – 9 Treatment

Trial ID: Rasp.Botrytis.9trt.2014 Protocol ID: Rasp.Botrytis.9trt.2014
Location: Whatcom Co Study Director: Tom Walters
Project ID: 2014 Investigator: Alan Schreiber
Sponsor Contact:

Pest Type				D Disease	D Disease	D Disease	D Disease
Pest Name				Botrytis sp.	Botrytis sp.	Botrytis sp.	Botrytis sp.
Crop Name				Red raspberry	Red raspberry	Red raspberry	Red raspberry
Part Rated				FRUIT -	FRUIT -	FRUIT -	FRUIT -
Description				100 berries	100 berries	100 berries	100 berries
Rating Type				Incidence	Severity	Incidence	Severity
Rating Unit				number	0-100	number	0-100
Rating Date				Jul-3-2014	Jul-3-2014	Jul-15-2014	Jul-15-2014
Trt No. Treatment Name	Rate	Rate Unit	Appl Code	1	2	3	4
1 Untreated Check				0.02 a	9.4 A	0.08 a	47.0 a
2 CAPTAN	2	lb/a	A	0.00 b	0.0 A	0.01 b	25.0 a
SWITCH	14	oz/a	A				
CAPTAN	2	lb/a	B				
PRISTINE	23	oz/a	B				
CAPTAN	2	lb/a	C				
CAPTAN	2	lb/a	D				
SWITCH	14	oz/a	D				
CAPTAN	2	lb/a	E				
Rovral	2	pt/a	E				
CAPTAN	2	lb/a	F				
SWITCH	14	oz/a	F				

Means followed by same letter do not significantly differ (P=.05, Duncan's New MRT)

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Pest Type				D Disease	D Disease	D Disease	D Disease
Pest Name				Botrytis sp.	Botrytis sp.	Botrytis sp.	Botrytis sp.
Crop Name				Red raspberry	Red raspberry	Red raspberry	Red raspberry
Part Rated				FRUIT -	FRUIT -	FRUIT -	FRUIT -
Description				100 berries	100 berries	100 berries	100 berries
Rating Type				Incidence	Severity	Incidence	Severity
Rating Unit				number	0-100	number	0-100
Rating Date				Jul-3-2014	Jul-3-2014	Jul-15-2014	Jul-15-2014
Trt No. Treatment Name	Rate	Rate Unit	Appl Code	1	2	3	4
3 CAPTAN	2.5	lb/a	A	0.00 b	0.0 A	0.00 b	0.0 a
SWITCH	14	oz/a	A				
CAPTAN	2.5	lb/a	B				
PRISTINE	23	oz/a	B				
CAPTAN	2.5	lb/a	C				
CAPTAN	2.5	lb/a	D				
SWITCH	14	oz/a	D				
CAPTAN	2.5	lb/a	E				
Rovral	2	pt/a	E				
SWITCH	14	oz/a	F				
4 CAPTAN	2.5	lb/a	A	0.01 b	10.0 A	0.01 b	25.0 a
CAPTAN	2.5	lb/a	B				
CAPTAN	2.5	lb/a	C				
SWITCH	14	oz/a	C				
CAPTAN	2.5	lb/a	D				
SWITCH	14	oz/a	D				
5 CAPTAN	2.5	lb/a	A	0.01 b	3.8 A	0.01 b	17.5 a
SWITCH	14	oz/a	A				
CAPTAN	2.5	lb/a	B				
CAPTAN	2.5	lb/a	C				
CAPTAN	2.5	lb/a	D				
SWITCH	14	oz/a	D				
6 CAPTAN	1.5	lb/a	A	0.00 b	0.0 A	0.00 b	0.0 a
CAPTAN	1.5	lb/a	B				
CAPTAN	1.5	lb/a	C				
CAPTAN	1.5	lb/a	D				
SWITCH	14	oz/a	D				

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Pest Type				D Disease	D Disease	D Disease	D Disease
Pest Name				Botrytis sp.	Botrytis sp.	Botrytis sp.	Botrytis sp.
Crop Name				Red raspberry	Red raspberry	Red raspberry	Red raspberry
Part Rated				FRUIT -	FRUIT -	FRUIT -	FRUIT -
Description				100 berries	100 berries	100 berries	100 berries
Rating Type				Incidence	Severity	Incidence	Severity
Rating Unit				number	0-100	number	0-100
Rating Date				Jul-3-2014	Jul-3-2014	Jul-15-2014	Jul-15-2014
Trt No. Treatment Name	Rate	Rate Unit	Appl Code	1	2	3	4
7 CAPTAN	1.25	lb/a	A	0.01 b	25.0 A	0.00 b	0.0 a
SWITCH	14	oz/a	A				
CAPTAN	1.25	lb/a	B				
PRISTINE	23	oz/a	B				
CAPTAN	2.5	lb/a	C				
CAPTAN	1.25	lb/a	D				
PRISTINE	23	oz/a	D				
CAPTAN	1.25	lb/a	E				
Rovral	2	pt/a	E				
CAPTAN	1.25	lb/a	F				
SWITCH	14	oz/a	F				
8 CAPTAN	2	lb/a	A	0.00 b	0.0 A	0.00 b	0.0 a
SWITCH	11.2	oz/a	A				
CAPTAN	2	lb/a	B				
PRISTINE	20	oz/a	B				
CAPTAN	2.5	lb/a	C				
CAPTAN	2	lb/a	D				
SWITCH	11.2	oz/a	D				
CAPTAN	2	lb/a	E				
Rovral	1	pt/a	E				
CAPTAN	2	lb/a	F				
SWITCH	11.2	oz/a	F				

Agriculture Development Group, Inc.

Pest Type				D Disease	D Disease	D Disease	D Disease
Pest Name				Botrytis sp.	Botrytis sp.	Botrytis sp.	Botrytis sp.
Crop Name				Red raspberry	Red raspberry	Red raspberry	Red raspberry
Part Rated				FRUIT -	FRUIT -	FRUIT -	FRUIT -
Description				100 berries	100 berries	100 berries	100 berries
Rating Type				Incidence	Severity	Incidence	Severity
Rating Unit				number	0-100	number	0-100
Rating Date				Jul-3-2014	Jul-3-2014	Jul-15-2014	Jul-15-2014
Trt No. Treatment Name	Rate	Rate Unit	Appl Code	1	2	3	4
9 CAPTAN	2	lb/a	A	0.01 b	1.3 A	0.02 b	15.8 a
SWITCH	14	oz/a	A				
CAPTAN	2	lb/a	B				
PRISTINE	23	oz/a	B				
CAPTAN	2.5	lb/a	C				
CAPTAN	2	lb/a	D				
SWITCH	14	oz/a	D				
PhD	6.2	oz/a	E				
Rovral	2	pt/a	E				
PhD	6.2	oz/a	F				
SWITCH	14	oz/a	F				
Standard Deviation				0.009	17.59	0.040	35.05
Replicate F				0.372	1.796	0.905	0.275
Replicate Prob(F)				0.7739	0.1748	0.4531	0.8429
Treatment F				2.023	0.901	1.484	0.866
Treatment Prob(F)				0.0870	0.5312	0.2148	0.5575

Trial Comments

The objective of this trial was to screen 20 fungicides or fungicide tank mixes against fungicidally resistant botrytis in a commercial raspberry operation. The 20 treatments were a compilation of industry standards, products new to the industry and some unregistered products. The products were selected by a group of industry representatives, a WSU plant pathologists, crop advisors and registrants. Products such as Ph.D. and Tavano are the same active ingredients but are different formulations. Switch, Captan, Elevate and Pristine are considered the industry standards. The field has documented resistance to Pristine and Elevate.

To understand this trial, one must understand that environmental conditions were considered exceptionally unfavorable for disease development. Crop advisors stated that this was a season with the lowest disease pressure that has been seen in recent memory. One crop advisor said that he has not seen this low of disease pressure in the 23 years he has worked in Whatcom County.

Applications commenced on May 27th at a prebloom timing and applications were made every 7 to 11 days depending on weather conditions and crop stage. All applications went on at approximately the correct time and applications went on with minimal issues. Subsequent applications were made on June 5th, June 16th, June 24th, July 2nd and July 11. An over the row sprayer was used (see photo below). Psi was 225 at the beginning of the season and was increased to 300 as canopy developed. 100 gallons of water was used per acre. Pressure sensitive paper was used in document that adequate coverage was achieved.

Botrytis did not show up in the trial until exceedingly late in the season with the first measureable levels detected on July 3rd, one day after the second to the last application. The untreated check had an incidence of 2% of berries with 9% of fruit covered with botrytis (data column 1). By comparison all fungicidal programs had only 1% or no botrytis. The programs that had 1% of berries with botrytis were Program 4 (Captan, Captan, Captan/Switch, Captan/Switch), Program 5 (Captan, Captan, Captan and Captan/Switch) and Program 7 (Captan/Switch, Captan/Pristine, Captan, Captan/Pristine, Captan/Rovral, Captan/Switch). The first two programs, 4 and 5, did not contain applications with the last two treatments and the incidence of botrytis is due to lack of any fungicides applied late in the season when the disease finally appeared. It is unclear why Program 7 did not completely eliminate botrytis as did the other full season programs.

Twelve days later (July 15), disease pressure in the untreated check had increased to 8% of berries having 47% of infected berries covered (data column 2). Considering this was at late harvest and no fungicides had been applied, this is considered relatively light disease pressure. (In this field, two years previous, this was would have been less than the average field rating using the most optimum seven treatment fungicidal spray program.) Every fungicidal program significantly reduced incidence of disease. Programs that completely eliminated botrytis were Program 3 (Captan/Switch, Captan/Pristine, Captan, Captan/Switch, Captan/Rovral, Switch), Program 6 (Captan, Captan, Captan, Captan/Switch) a Program that had some disease in the previous sampling, and Program 7 (Captan/Switch, Captan/Pristine, Captan, Captan/Pristine, Captan/Rovral, Captan/Switch) which also had a low incidence of disease in the previous sampling and Program 8 (Captan/Switch, Captan/Pristine, Captan, Captan/Switch, Captan/Roval, Captan/Switch).

Conclusions.

Because disease pressure was so low in this trial one must take care with extrapolating results from the 2014 data to years with more typical disease pressure. The basic conclusion that in years of low disease pressure, all fungicidal programs will significantly reduce incidence and severity of fungicidally resistant botrytis. Programs that have fewer than six applications run the risk of disease developing during periods where conditions are favorable for disease development and gaps in coverage exist.

Agriculture Development Group, Inc.

Raspberry Botrytis Field Efficacy Program - 21 Treatments - 2014

Trial ID: Rasp.Botry.21trt-2014 Protocol ID: Rasp.Botry.21trt-2014
Location: Everson, WA Study Director: Tom Walters
Project ID: Investigator: Alan Schreiber
Sponsor Contact: Various

General Trial Information

Study Director: Tom Walters **Title:** Ag Researcher
Investigator: Alan Schreiber **Title:** President

Discipline: F fungicide
Trial Status: I one-year/interim **Trial Reliability:** GOOD
Initiation Date: Mar-31-2014 **Planned Completion Date:** Oct-15-2014

Trial Location:

City: Everson Near Everson, Washington
State/Prov.: Washington
Country: USA United States
Directions: This trial is located on the Samson Farms property, at the corner of Noon Road and Vandyke Rd, in Whatcom County, Washington.

Objectives:

To test the efficacy of various fungicides for control of botrytis in raspberry.

Personnel

Study Director: Tom Walters **Title:** Ag Researcher
Affiliation: Walters Ag Research
Address: 2117 Meadows Lane
Location: Anacortes Washington
Postal Code: 98221 **E-mail:** waltersagresearch@frontier.com
Phone No.: 360-420-2776
Investigator: Alan Schreiber **Title:** President
Affiliation: Agriculture Development Group, Inc.
Address: 2621 Ringold Road
Location: Eltopia, WA
Postal Code: 99330 **E-mail:** aschreib@centurytel.net
Phone No.: 509-266-4348 **Mobile No.:** 509-539-4537

Agriculture Development Group, Inc.

Crop Description

Crop 1: RUBID Rubus idaeus Red raspberry
Variety: Meeker
BBCH Scale: BPER
Planting Method: ESTABL established

Pest Description

Pest 1 Type: D **Code:** BOTRSP Botrytis sp.
Common Name: Botrytis sp.

Site and Design

Plot Width, Unit: 10 FT **Site Type:** FIELD field
Plot Length, Unit: 30 FT **Experimental Unit:** 1 PLOT plot
Plot Area, Unit: 300 FT2 **Tillage Type:** NOTILL no-till
Replications: 4 **Study Design:** RACOBL Randomized Complete Block (RCB)
Untreated Arrangement: INCLUDED single control randomized in each block

Application Description

	A	B	C	D	E	F
Application Date:	May-27-2014	Jun-5-2014	Jun-16-2014	Jun-24-2014	Jul-2-2014	Jul-11-2014
Time of Day:	7am	8am	10am	7am	9am	8am
Application Method:	SPRAY	SPRAY	SPRAY	SPRAY	SPRAY	SPRAY
Application Timing:	7 Day Interval	7 Day Interval	7 Day Interval	7 Day Interval	7 Day Interval	7 Day Interval
Application Placement:	FOLIAR	FOLIAR	FOLIAR	FOLIAR	FOLIAR	FOLIAR
Applied By:	Tom Walters	Tom Walters	Tom Walters	Tom Walters	Tom Walters	Tom Walters
Air Temperature, Unit:	55 F	62 F	60 F	64 F	72 F	68 F
Wind Velocity, Unit:	0 MPH	0 MPH	2 MPH	2 MPH	3 MPH	0 MPH
Wind Direction:			W	SW	NW	

Crop Stage At Each Application

	A	B	C	D	E	F
Crop 1 Code, BBCH Scale:	RUBID BPER	RUBID BPER	RUBID BPER	RUBID BPER	RUBID BPER	RUBID BPER

Pest Stage At Each Application

	A	B	C	D	E	F
Pest 1 Code, Type, Scale:	BOTRSP D	BOTRSP D	BOTRSP D	BOTRSP D	BOTRSP D	BOTRSP D

Agriculture Development Group, Inc.

Application Equipment						
	A	B	C	D	E	F
Appl. Equipment:	OverRowBoom	OverRowBoom	OverRowBoom	OverRowBoom	OverRowBoom	OverRowBoom
Equipment Type:	SPRAYR	SPRAYR	SPRAYR	SPRAYR	SPRAYR	SPRAYR
Operation Pressure, Unit:	225 psi	225 psi	225 psi	300 psi	300 psi	300 psi
Nozzle Type:	Tee-Jet	Tee-Jet	Tee-Jet	Tee-Jet	Tee-Jet	Tee-Jet
Nozzle Size:	D-3	D-3	D-3	D-3	D-3	D-3
Nozzle Spacing, Unit:	12 in	12 in	12 in	12 in	12 in	12 in
Nozzles/Row:	12	12	12	12	12	12
Band Width, Unit:	6 ft	6 ft	6 ft	6 ft	6 ft	6 ft
Boom Length, Unit:	6 FT	6 FT	6 FT	6 FT	6 FT	6 FT
Ground Speed, Unit:	2.5 mph	2.5 mph	2.5 mph	2.5 mph	2.5 mph	2.5 mph
Carrier:	WATER	WATER	WATER	WATER	WATER	WATER
Spray Volume, Unit:	100 gal/ac	100 gal/ac	100 gal/ac	100 gal/ac	100 gal/ac	100 gal/ac
Mix Size, Unit:	13 liters	13 liters	13 liters	13 liters	13 liters	13 liters

Agriculture Development Group, Inc.

Raspberry Botrytis Field Efficacy Program – 21 Treatments - 2014

Trial ID: Rasp.Botry.21trt-2014 Protocol ID: Rasp.Botry.21trt-2014
Location: Everson, WA Study Director: Tom Walters
Project ID: Investigator: Alan Schreiber
Sponsor Contact: Various

Reps: 4 Plots: 10 by 30 feet
Spray vol: 100 gal/ac Mix size: 12.55 liters (min 12.514)

Trt No.	Treatment Name	Form Conc	Form Type	Description	Rate	Rate Unit	Appl Code	Amt Product to Measure	Rep 1	2	3	4
1	Untreated Check			not treated					101	221	302	413
2	PhD	11.3	WG		6.2	oz/a	ABCDEF	4.842 g/4 pl	102	211	304	418
3	TAVANO	5	SC		13	fl oz/a	ABCDEF	10.59 ml/4 pl	103	201	312	405
4	REGALIA	5	SC		4	qt/a	ABCDEF	104.3 ml/4 pl	104	212	313	421
5	OMEGA	4.17	EC		1.25	pt/a	ABCDEF	16.29 ml/4 pl	105	207	305	412
6	MERIVON	4.18	EC		5.5	fl oz/a	ABCDEF	4.481 ml/4 pl	106	220	317	419
7	LUNA SENSATION	4.2	EC		5.5	fl oz/a	ABCDEF	4.481 ml/4 pl	107	219	311	417
8	Luna Tranquility	45	L		24	fl oz/a	ABCDEF	19.55 ml/4 pl	108	218	301	406
9	SCALA	54.6	SC		18	fl oz/a	ABCDEF	14.66 ml/4 pl	109	208	321	411
10	SWITCH	62.5	WG		14	oz/a	ABCDEF	10.93 g/4 pl	110	204	306	404
11	CAPTAN	80	WG		2.5	lb/a	ABCDEF	31.24 g/4 pl	111	203	319	416
12	ELEVATE	50	WG		1.5	lb/a	ABCDEF	18.74 g/4 pl	112	206	309	408
13	PRISTINE	38	WG		23	oz/a	ABCDEF	17.96 g/4 pl	113	214	303	407
14	IPRODIONE	4	SL		1	fl oz/a	ABCDEF	0.8147 ml/4 pl	114	210	307	415
15	BRAVO Weatherstik	6	SC		4	pt/a	ABCDEF	52.13 ml/4 pl	115	213	316	403
16	V-10135	3.34	SC		0.375	lb ai/a	ABCDEF	11.71 ml/4 pl	116	209	310	420
17	PROTEXIO	3.34	SC		0.375	lb ai/a	ABCDEF	11.71 ml/4 pl	117	215	320	401
18	PROTEXIO	3.34	SC		0.5	lb ai/a	ABCDEF	15.61 ml/4 pl	118	202	318	409
19	PROTEXIO	3.34	SC		0.375	lb ai/a	ACE	11.71 ml/4 pl	119	205	308	402
	SWITCH	62.5	WG		0.43	lb ai/a	BDF	8.597 g/4 pl				
20	ELEVATE	50	WG		0.75	lb ai/a	ACE	18.74 g/4 pl	120	217	314	410
	SWITCH	62.5	WG		0.43	lb ai/a	BDF	8.597 g/4 pl				
21	PROLINE	4	EC		5	fl oz/a	ABCDEF	4.073 ml/4 pl	121	216	315	414

Sort Order: Replicate 1

Agriculture Development Group, Inc.

Raspberry Botrytis Field Efficacy Program – 21 Treatments - 2014

Trial ID: Rasp.Botry.21trt-2014 Protocol ID: Rasp.Botry.21trt-2014
Location: Everson, WA Study Director: Tom Walters
Project ID: Investigator: Alan Schreiber
Sponsor Contact: Various

Product quantities required for listed treatments and applications of trials included in this table:

Amount*	Unit	Treatment Name	Form Conc	Form Type	Lot Code
31.958	g	PhD	11.3	WG	
69.901	ml	TAVANO	5	SC	
688.255	ml	REGALIA	5	SC	
107.528	ml	OMEGA	4.17	EC	
29.574	ml	MERIVON	4.18	EC	
29.574	ml	LUNA SENSATION	4.2	EC	
129.048	ml	Luna Tranquility	45	L	
96.786	ml	SCALA	54.6	SC	
128.902	g	SWITCH	62.5	WG	
206.177	g	CAPTAN	80	WG	
185.560	g	ELEVATE	50	WG	
118.552	g	PRISTINE	38	WG	
5.377	ml	IPRODIONE	4	SL	
344.091	ml	BRAVO Weatherstik	6	SC	
77.266	ml	V-10135	3.34	SC	
218.920	ml	PROTEXIO	3.34	SC	
26.885	ml	PROLINE	4	EC	

* 'Per area' calculations based on 4 replicates of 10 by 30 feet 'Plot' experimental units (area of one treatment).
* 'Per area' calculations based on spray volume= 100 gal/ac, mix size= 12.55 liters (mix size basis).
* Product amount calculations increased 10 % for overage adjustment.
* Adjusted for multiple applications in treatment list.

Agriculture Development Group, Inc.

Raspberry Botrytis Field Efficacy Program -21 Treatments - 2014

Trial ID: Rasp.Botry.21trt-2014 Protocol ID: Rasp.Botry.21trt-2014
Location: Everson, WA Study Director: Tom Walters
Project ID: Investigator: Alan Schreiber
Sponsor Contact: Various

Pest Type				D Disease	D Disease	D Disease	D Disease
Pest Name				Botrytis sp.	Botrytis sp.	Botrytis sp.	Botrytis sp.
Crop Name				Red raspberry	Red raspberry	Red raspberry	Red raspberry
Part Rated				FRUIT -	FRUIT -	FRUIT -	FRUIT -
Description				100 berries	100 berries	100 berries	100 berries
Rating Type				Incidence	Severity	Incidence	Severity
Rating Unit				Number	0-100	Number	0-100
Rating Date				Jul-3-2014	Jul-3-2014	Jul-15-2014	Jul-15-2014
Trt No. Treatment Name	Rate	Rate Unit	Appl Code	1	2	3	4
1 Untreated Check				0.07 a	23.3 A	0.13 a	83.3 a
2 PhD	6.2	oz/a	ABCDEF	0.02 b	16.3 A	0.02 bc	11.7 bc
3 TAVANO	13	fl oz/a	ABCDEF	0.01 b	1.3 A	0.03 bc	37.5 abc
4 REGALIA	4	qt/a	ABCDEF	0.06 a	13.0 A	0.08 ab	72.8 ab
5 OMEGA	1.25	pt/a	ABCDEF	0.02 b	4.2 A	0.02 bc	50.0 abc
6 MERIVON	5.5	fl oz/a	ABCDEF	0.00 b	0.0 A	0.01 bc	15.0 bc
7 LUNA SENSATION	5.5	fl oz/a	ABCDEF	0.00 b	0.0 A	0.01 bc	25.0 abc
8 Luna Tranquility	24	fl oz/a	ABCDEF	0.00 b	0.0 A	0.01 bc	2.5 c
9 SCALA	18	fl oz/a	ABCDEF	0.00 b	0.0 A	0.00 c	0.0 c

Means followed by same letter do not significantly differ (P=.05, Duncan's New MRT)

Agriculture Development Group, Inc.

Pest Type				D Disease	D Disease	D Disease	D Disease
Pest Name				Botrytis sp.	Botrytis sp.	Botrytis sp.	Botrytis sp.
Crop Name				Red raspberry	Red raspberry	Red raspberry	Red raspberry
Part Rated				FRUIT -	FRUIT -	FRUIT -	FRUIT -
Description				50 berries	50 berries	50 berries	50 berries
Rating Type				Incidence	Severity	Incidence	Severity
Rating Unit				Number	0-100	Number	0-100
Rating Date				Jul-3-2014	Jul-3-2014	Jul-15-2014	Jul-15-2014
Trt No. / Treatment Name	Rate	Rate Unit	Appl Code	1	2	3	4
10 SWITCH	14	oz/a	ABCDEF	0.01 b	2.5 A	0.02 bc	35.0 abc
11 CAPTAN	2.5	lb/a	ABCDEF	0.01 b	1.3 A	0.02 bc	46.3 abc
12 ELEVATE	1.5	lb/a	ABCDEF	0.02 b	3.8 A	0.06 bc	24.5 abc
13 PRISTINE	23	oz/a	ABCDEF	0.00 b	0.0 A	0.02 bc	20.5 abc
14 IPRODIONE	1	fl oz/a	ABCDEF	0.02 b	21.3 A	0.02 bc	16.5 bc
15 BRAVO Weatherstik	4	pt/a	ABCDEF	0.01 b	3.8 A	0.02 bc	38.8 abc
16 V-10135	0.375	lb ai/a	ABCDEF	0.02 b	11.7 A	0.03 bc	48.0 abc
17 PROTEXIO	0.375	lb ai/a	ABCDEF	0.02 b	6.6 A	0.02 bc	43.8 abc
18 PROTEXIO	0.5	lb ai/a	ABCDEF	0.02 b	7.5 A	0.00 c	0.0 c
19 PROTEXIO SWITCH	0.375 0.43	lb ai/a lb ai/a	ACE BDF	0.01 b	18.8 A	0.00 c	0.0 c
20 ELEVATE SWITCH	0.75 0.43	lb ai/a lb ai/a	ACE BDF	0.00 b	0.0 A	0.00 c	0.0 c

Agriculture Development Group, Inc.

Pest Type				D Disease	D Disease	D Disease	D Disease
Pest Name				Botrytis sp.	Botrytis sp.	Botrytis sp.	Botrytis sp.
Crop Name				Red raspberry	Red raspberry	Red raspberry	Red raspberry
Part Rated				FRUIT -	FRUIT -	FRUIT -	FRUIT -
Description				50 berries	50 berries	50 berries	50 berries
Rating Type				Incidence	Severity	Incidence	Severity
Rating Unit				Number	0-100	Number	0-100
Rating Date				Jul-3-2014	Jul-3-2014	Jul-15-2014	Jul-15-2014
Trt No. Treatment Name	Rate	Rate Unit	Appl Code	1	2	3	4
21 PROLINE	5	fl oz/a	ABCDEF	0.00 b	1.5 A	0.03 bc	35.2 abc
Standard Deviation				0.023	15.99	0.041	38.58
Replicate F				0.705	1.114	0.889	1.064
Replicate Prob(F)				0.5531	0.3507	0.4524	0.3714
Treatment F				2.396	0.927	2.134	1.511
Treatment Prob(F)				0.0050	0.5574	0.0129	0.1120

Trial Comments

The objective of this trial was to screen 20 fungicides or fungicide tank mixes against fungicidally resistant botrytis in a commercial raspberry operation. The 20 treatments were a compilation of industry standards, products new to the industry and some unregistered products. The products were selected by a group of industry representatives, a WSU plant pathologists, crop advisors and registrants. Products such as Ph.D. and Tavano are the same active ingredients but are different formulations. Switch, Captan, Elevate and Pristine are considered the industry standards. The field has documented resistance to Pristine and Elevate.

To understand this trial, one must understand that environmental conditions were considered exceptionally unfavorable for disease development. Crop advisors stated that this was a season with the lowest disease pressure that has been seen in recent memory. One crop advisor said that he has not seen this low of disease pressure in the 23 years he has worked in Whatcom County.

Applications commenced on May 27th at a prebloom timing and applications were made every 7 to 11 days depending on weather conditions and crop stage. All applications went on at approximately the correct time and applications went on with minimal issues. Subsequent applications were made on June 5th, June 16th, June 24th, July 2nd and July 11. An over the row sprayer was used (see photo below). Psi was 225 at the beginning of the season and was increased to 300 as canopy developed.

100 gallons of water was used per acre. Pressure sensitive paper was used in document that adequate coverage was achieved.

Botrytis did not show up in the trial until exceedingly late in the season with the first measureable levels detected on July 3rd, one day after the second to the last application. At that time, the untreated check had 7% of berries infected with an average severity of 23% of berries covered with botrytis. Every fungicidal treatment significantly reduced incidence of botrytis with exception of Regalia at 4 quarts. Every other of the 19 fungicidal treatments significantly reduced botrytis down to 2%, 1% or eliminated botrytis. Treatments that eliminated botrytis at this sampling interval were Luna Sensation, Luna Tranquility, Scala, Pristine, Elevate tank mixed with Switch, and Proline. Severity ratings were more complicated due to the high level of variability in among treatments-an occurrence that is not uncommon in very low pressure situations. Treatments with the highest level of severity at the first rating included PhD, Regalia, Iprodione, V-10135 and Protexio tank mixed with Switch. Because of the high degree of variability, one must draw too strong of conclusions from the this particular rating.

Twelve days later (July 15), disease pressure in the untreated check had increased to 13% of berries having 83% of infected berries covered. Considering this was at late harvest and no fungicides had been applied, this is considered relatively light disease pressure. (In this field, two years previous, this was would have been the average field rating using the most optimum seven treatment fungicidal spray program.) Every fungicidal program significantly reduced incidence of disease with the exception of the Regalia program. If six applications of Regalia at the high rate was not effective in such a low disease pressure situation, then it should not be considered an option. Regalia is a fungicide with known efficacy against botrytis (I have demonstrated this on botrytis in grapes), however it probably does not have an adequate period of residual activity to provide control of botrytis when applied at these intervals. All remaining fungicide programs had incidence of botrytis at 3%, 2%, 1% or eliminated botrytis. Fungicidal programs with no botrytis were Scala, Protexio, Protexio tank mixed with Switch and Elevate tank mixed with Switch.

Unlike the previous severity rating there were significant differences between the untreated check and several fungicidal programs. Obviously the four programs with no incidence of disease had zero severity, but other programs with the lowest severity were Luna Tranquality, PhD, Merivon and Iprodione.

Based on this trial, the following conclusions were drawn.

- Because this was such a low pressure situation, one should not expect similar results in a heavy botrytis disease pressure situation.

- The trial needs to be conducted again in a heavy disease pressure situation.
- Regalia may not have a fit in conventional raspberry botrytis control programs.
- Conversations should be started with the manufacturers of Scala and Luna products (Bayer) and Protexio (Valent) to see if registrations could be obtained on raspberries.
- Although Bayer has been approached regarding Proline and they were not enthusiastic regarding a registration on raspberry, but it is premature to accept no as an answer at this time.

Photos 1 and 2. The photo on the left is application 4 and the photo on the right corresponding test paper showing adequate coverage.


Photos 3 and 4. The photo on the left shows the first application and the photo on the right shows a corresponding water sensitive paper.

Project Proposal to WRRC **Proposed Duration:** 2014-2015

Project Title: Management of Fungicide Resistant Botrytis in Red Raspberry

PI: Alan Schreiber
Organization: Agriculture Development Group, Inc.
Title: Researcher
Phone: 509 266 4348 (office), 509 59 4537 (cell)
Email: aschreib@centurytel.net
Address: 2621 Ringold Road, Eltopia, WA 99330

Cooperators: Dr. Tobin Peever-WSU, Tom Walters-Walters Ag Research

Year Initiated: 2013 **Current Year:** 2014 **Terminating Year:** 2015

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

Other Funding Sources: I plan to submit a parallel proposal to the Washington State Commission on Pesticide Registration for $15,000. I expect that registrants will be involved in this project and will contribute but how much this could be is not known.

Description: Resistance has been documented to three of five active ingredients used for control of botrytis in 2012. The project proposes to screen currently used products, other products that are registered but not used and products not registered for raspberry for control of botrytis. This project will be a basic efficacy trial that is based on the 2013 trial, but with some improvements based on what was learned during the course of this trial. Disease pressure in 2014 was extraordinarily low and limited the amount of useful data that could be generated.

Justification and Background: This project will generate data on which fungicidal products are effective for control of botrytis and which products are not. Dr. Peever will take the lead on berry pathology work and at this time does not plan to take the lead on efficacy trials in raspberries. Based on a conversation in 2013 and in the fall of 2014, he does not plan to conduct any efficacy trials in raspberries. I am submitting this proposal at the request of the WRRC to ensure that the necessary information is generated for the raspberry industry of Washington. It is our expectation as in berry pathology expertise is developed in Washington there will be less of a need for out of state assistance. We plan to coordinate our work with Oregon State University.

Botrytis cinerea, is a fungus that causes blossom blight, preharvest rot, postharvest rot, and cane infections. On raspberry, it overwinters as sclerotia on canes and mycelia in dead leaves and mummified fruit. Sclerotia produce conidia in spring. A moist, humid environment is ideal for pathogen sporulation and spread. All flower parts except sepals are very susceptible. Initial infections of flowers are latent such that the fungus is dormant until fruit ripens. Fruit rot may be more prevalent in wet weather, in fields under overhead set irrigation systems, or where fruit ripens in the field for mechanical harvest. Conidia can infect mature or senescent leaves, resulting in primocane infections through petioles.

This is the most treated for disease of berries in Washington with growers applying three to six applications per season starting with a prebloom application and continuing through to harvest. (Raspberry growers who are applying only three or four applications are probably incurring significant economic losses from the disease.) There is no threshold for this disease. If you find it, think you have it or are at risk of having it, you have to start a treatment program. The PNW Small Fruit Research Center ranks it as a number one priority for research for blueberry and raspberry. Raspberry and blueberry have the same disease, are planted adjacent to each other and have the same fungicides used for control of the pest. Raspberry has fruit that is susceptible earlier than blueberry and has heavier selection pressure. It is likely that spores that survive raspberry fungicide programs infect blueberry fields that mature later and then are subjected to another fungicide program in the same season.

Despite aggressive treatment programs, growers incur annual losses to the pest. Botrytis is well known for developing resistance to fungicides. Growers, crop advisors, researchers and extension representatives are concerned that resistance may be developing. The PNW Disease Management Handbook states this about Botrytis on raspberry "Fungal strains can become tolerant to a fungicide when it is used exclusively in a spray schedule. To reduce the possibility of tolerance, alternate or tank-mix fungicides that have different modes of action. Strains resistant to 5 different modes of action have been reported from Germany." Based on complaints of poor control in 2011, Dr. Christopher Clemens, Technical Service Representative, Syngenta Crop Protection, worked with berry crop advisors and collected infected raspberry fruit from northwest Washington and submitted them to UC-Davis plant pathologist, Dr. Jim Adaskavig to challenge the diseased fruits for tolerance to fungicides. Samples were collected from nine fields and ten isolates from each of the nine fields were screened.

Pristine (boscalid+pyraclostrobin), Captan, Elevate (fenhexamid) and Switch (cyprodinil+fludioxonil) are the four products used for Botrytis control. Fifteen percent of isolates from five fields were found to be resistant to boscalid. Pyraclostrobin does not have efficacy against botrytis to start and is not a factor in this conversation. Every isolate from every field came back resistant to fenhexamid. Twelve percent of isolates from four fields were resistant to cyprodinil. No isolates were resistant to fludioxonil. These results were a source of great concern to the industry. What made these results more worrisome for the industry is the fact that there are almost no new products that have potential for registration on raspberries that have a mode of action different from existing products. Additional concerns for the industry are limitations placed on growers due to MRL restrictions. Due to MRL issues, some products have limited use (e.g. berries going to Canada cannot have any captan residues: Canada is the number one export market for Whatcom County raspberries.)

Growers try using all four products (some can only use three products due to MRLs) during a season for resistance management and due to label restrictions such as number of application restrictions, REI and PHIs. The loss of even one product (which is being proposed for fenhexamid) could mean a significant problem; the loss of two products would cause a crisis in the industry.

Relationship to WRRC Research Priority: This directly addresses the fruit rot priority.

Objectives: Our objective is to generate botrytis efficacy data for as many products as is possible for red raspberry. A secondary objective is to use this data and information provided by Dr. Peever to develop better Botrytis control recommendations for raspberry.

Procedures: It is my experience (AAS) that it generally requires 3 years to get an adequeate assessment of what products work for a particular pest. We plan to conduct efficacy trials in 2014 and 2015. The testing techniques would be similar to that of 2013 with some improvements. Although testing details have not been finalized, we would like to use the same site as in 2013 and 2014. Two trials were conducted in 2013 and 2014; one trial looked primarily at single ingredient programs to ascertain how that particular product worked against botrytis. The second trial evaluated 8 different programs used by the Whatcom County raspberry industry. The 8 programs covered the breadth of contract strategies used by growers. The trials took placed in a location that had documented fungicidal resistant botrytis.

The logic for two trials are that for un registered products unfamiliar to raspberry could be easily screened and would require crop destruct and a fuller trial that is season long would be done with registered products or products that did not require a crop destruct. Accordingly, we propose to conduct two trials in 2015, one that would a screen for new products and a second trial that would evaluate season long programs that are currently being used by growers. A commercial style applicator would be used. Each treatment would be replicated four times.

Applications would start prebloom and would continue into harvest. The start and end data and number of application depends on environmental and weather conditions and disease pressure. Botrytis samples from the trial plots will be provided to Dr. Peever to determine the degree of resistance to various fungicides. Dr. Tom Walters would be involved in applying fungicides. Schreiber would oversee the trial, collect and analyze the data and generate research reports.

The experimental design, including products and treatments, used in the 2014 trial will serve as the base for the 2015 trial. Scientists involved in project will meet with raspberry industry members and discuss what adjustments should be made to improve the trial. (It is expected that the 2015 trial will be similar to what was done in 2014.)

Anticipated Benefits and Information Transfer: We would provide a written report to the WRRC, would make a presentation at the Small Fruit Conference and would work closely with

WSU extension, crop advisors and members of the raspberry industry to make sure the outcome of the research was well known through the grower community.

Budget:	2014	2015
Salaries		
Operations		11,000
Travel		1,000
Total	$12,000	$12,000

These funds would funds would be primarily be used to cover the time of Schreiber and Walters spend on the project. It would cover the applicator's time, tractor/equipment usage, product purchases and other costs. WSCPR funds would be used fund the effort to make applications and collect data. All travel is related to travel to the site or meeting with industry representatives.

Chemical company funds would be used to support the grower/crop destruct, travel and operational costs (buy product that is not donated, etc)

Related Information.

Results from 2013. Unfortunately, we are still waiting on results from the raspberry, blueberry and strawberry survey results from University of California Riverside. The efficacy data are complete and a final report is nearing completion. The mid season evaluations indicated that most products, even Elevate, provided significant control of botrytis. Some experimental products clearly did not. Some biofungicides were largely ineffective. Unfortunately disease pressure collapsed during harvest so it was hard to distinguish much difference between products based on the yield data. We some areas for improvement in 2013 including increasing sample size of berries in the mid season evaluation and changing our evaluation methods at harvest particularly if the disease is not present at a high level.

Results from 2014. Unfortunately, disease pressure in 2014 was extraordinarily low. Disease was not detected in the trials until very late in the season and then it was quite low. Virtually every fungicidal provided a significant level of control. The one product that did not provide control, Regalia, should probably be considered a marginally effective product at best, and probably not considered an option by conventional growers. Some new active ingredients were identified that had activity against botrytis in a very low pressure situation. These products have new modes of action so they if proven efficacious they may be of great interest to the industry. We feel that the products, treatments and experimental design of 2014 would be suitable for the 2015 trial. The principals of this trial would meet with industry representatives to review the 2015 treatments to ascertain if any adjustments or improvements could be made.

Washington Red Raspberry Commission
Progress Report 2014

Project No: 3061-4303

Title: Biology and control of *Botrytis* fruit rot of red raspberry

Personnel: Tobin L. Peever, Associate Professor, Dalphy Harteveld, Post-Doctoral Associate, Olga Kozhar, PhD student

Reporting Period: January 2014 to November 2014

Accomplishments: Sampling of raspberry flowers and fruit from two sites during May and June 2014 in order to assess timing of *Botrytis cinerea* infection. Discovery of extensive colonization of raspberry floral parts by two *Cladosporium* species which might prevent *Botrytis* infection of these floral parts and throw into question previous data regarding routes of infection of raspberry flowers by *Botrytis*. Screening of approximately 150 *Botrytis* isolates sampled from dormant raspberry canes for resistance to 5 fungicides commonly used for *Botrytis* control in raspberry.

Results: Raspberry flowers and fruit were sampled from two raspberry fields during May and June 2014 to assess timing of *Botrytis* infection. One field site received intensive fungicide applications for *Botrytis* control while the other site received no fungicide sprays. Little *Botrytis* infection of flowers and immature fruit was detected in both locations. Maturing fruit had a higher incidence of *Botrytis* infection and surface disinfestation of fruit resulted in higher rates of *Botrytis* infection compared to fruit that was not surface disinfested suggesting an external route of infection in addition to infections occurring during flowering. Stigmas and styles of flowers from both field sites were extensively colonized by *Cladosporium cladosporioides* and *C. herbarum* and not by *Botrytis.* Colonization of these floral parts by *Cladosporium* is hypothesized to exclude colonization by *Botrytis* and raises questions about the ability of *Botrytis* to infect flowers through these organs as has been previously reported. Fungicide resistance assays were performed on approximately 150 isolates of *Botrytis* sampled from dormant raspberry canes in November 2014. These assays revealed widespread insensitivity to most fungicides used to control *Botrytis* in red raspberry. Isolates with high levels of insensitivity to fenhexamid (tradename: "Elevate") were detected in every field sampled in Whatcom Co. and made up the majority of isolates in several fields. These insensitive isolates had EC_{50} values of approximately 30 ppm, similar to isolates detected in Europe and associated with Elevate control failures. Isolates with moderate levels of insensitivity to iprodione ($EC_{50} \sim 3$ ppm) were detected throughout Whatcom Co. but no highly insensitive isolates were detected. A very low number (6 of 150) of isolates with reduced sensitivity to fludioxonil (one component of "Switch") were detected but EC_{50} values were low ($EC_{50} < 1$ ppm). Less sensitive isolates were common to cyprodinil (second component of "Switch") and boscalid (component of "Pristine") and EC_{50} values are currently being estimated. Substantial field-to-field variation was observed in insensitivity to cyprodinil and boscalid suggesting that usage patterns of Pristine and Switch may vary significantly from field to field resulting in large differences in selection for insensitivity.

Publications: No publications have resulted from this work to date

2015 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

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

Project Title: Biology of *Botrytis* causing fruit rot of red raspberry and fungicide resistance

PI: Tobin L. Peever
Organization: Department of Plant Pathology, Washington State University
Title: Associate Professor
Phone: 509-335-3754
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Address: P.O. Box 646430
City/State/Zip: Pullman, WA 99164-6430

Year Initiated __2014__ **Current Year** __2015__ **Terminating Year** __2016__

Total Project Request: Year 1 **$22,614** Year 2 **$23,198**

Other funding sources: Washington State Commission on Pesticide Registration, Northwest Center for Small Fruits Research

Description

The objective of this project is to improve management of Botrytis fruit rot of raspberry. Despite intensive fungicide application programs aimed at control of this disease in the US PNW, it is estimated that fruit losses and downgrades in fruit quality exceed 25% of the harvestable fruit due to incomplete disease control. Additionally, fungicides used for control are losing effectiveness due to the development of resistance, further limiting management options. Applications of fungicides in the PNW are currently timed on a calendar basis rather than according to infection risk largely because the life cycle of the pathogen and the infection process are poorly understood. Specific **outcomes** of this project will include a detailed study of the disease cycle of *Botrytis cinerea* infecting raspberry and identification of environmental factors controlling the infection process. Simultaneously, we will continue our survey for resistance to fungicides currently used to Botrytis fruit rot control. This will provide important baseline data necessary for the design of control strategies to minimize the development of fungicide resistance and improve disease control.

Justification and Background

Current control strategies for Botrytis fruit rot of raspberry in WA involve up to 7 fungicide sprays at an average cost of $75 per application per acre. Despite this intensive fungicide application schedule, fruit losses average 20-25% in disease-conducive years suggesting that much improvement in disease control is possible. The intensity of fungicide spray programs currently used to control Botrytis fruit rot in raspberry, coupled with the appearance of fungicide resistant isolates, suggests that improved control strategies are needed.

Reducing the number of fungicide applications while maintaining or improving disease control will improve profitability for producers and reduce selection pressure for resistance. Improved Botrytis fruit rot control will depend on a much greater understanding of the life cycle of the pathogen and a better understanding of the current levels of resistance to fungicides used for Botrytis fruit rot control and control of other fungal pathogens in PNW raspberries.

Botrytis fruit rot results from infections of mature raspberry fruit by *B. cinerea* but the initial source of the pathogen is thought to be latent or quiescent infections of floral parts (Dashwood & Fox 1988, Jarvis 1962). The fungus infects open flowers but remains latent before moving into ripening fruit. The majority of fruit infections of both strawberry and raspberry appear to result from latent floral infections (Bristow et al. 1986, Jarvis 1962). Open flowers are rapidly colonized by *B. cinerea* and necrotic stamens and styles are an important source of inoculum for fruit rot (Dashwood & Fox 1988, McNicol et al. 1985). A fungicide timing study in raspberry showed that restriction of fungicide applications to the bloom period resulted in more Botrytis fruit rot compared to sprays applied throughout the season (Ellis et al 2008). This result may indicate that the infection window for raspberry is longer than that of strawberry and not necessarily restricted to the flowering stage. The effect of machine harvesting on Botrytis fruit rot of raspberry has not been investigated but it has been suggested that successive machine harvestings may wound developing fruit allowing airborne *Botrytis* to invade fruit from the exterior or allowing *Botrytis* spores on the surface of ripening fruit a chance to penetrate the fruit (McNicol et al. 1990, Williamson & McNicol 1986).

Five classes of fungicides are currently registered for control of *Botrytis cinerea* on small fruit worldwide (Williamson et al. 2007) and in the US PNW (Coyne et al. 2012). Most of these are at high risk for resistance development due to their specific modes of action. Intensive spray programs are expected to select strongly for resistance. *B. cinerea* sampled from German strawberry fields were resistant to up to 6 different fungicides (Leroch et al. 2013) and 15 to 80% of *B. cinerea* isolates sampled from raspberry, blueberry, currants and strawberry fields in northern Germany were each resistant to one of five different fungicides and 18% were resistant to all five fungicides (Weber 2011). These results indicate that fungicide resistance can be a severe problem in small fruit production and that measures are required to reduce selection pressure in order to extend the useful lifespan of these chemicals. Currently there is no published data on levels of resistance to fungicides used to control Botrytis fruit rot and other fungal diseases of raspberry in the US PNW but anecdotal reports suggest reductions in efficacy of certain products.

Relationship to WRRC Research Priorities

This research project addresses one of the #1 priorities of the WRRC namely "*Fruit rot including pre harvest, post harvest, and/or shelf life*".

Objectives

1) Study the dynamics of flower and fruit infection by *Botrytis cinerea* during the growing season particularly in relation to machine harvesting

2) Determine baseline resistance levels to fungicides commonly used for control of Botrytis fruit rot

Procedures

1) Infection process of *Botrytis cinerea* causing gray mold of red raspberry

Raspberry flowers and fruit will be sampled from raspberries growing under natural rainfall and mist irrigation at WSU's Mount Vernon Research Center and at the Samson Efficacy trial field as well as several commercial production fields during the growing season. Flowers and fruit will be sampled weekly starting at the onset of flowering until harvest. Flowers and fruit will be dissected to estimate *Botrytis* colonization of individual parts. Samples will be surface disinfested and placed in moist chambers to induce sporulation (Boyd-Wilson et al. 2013) and also plated on agar media (Dashwood & Fox 1988) to isolate *B. cinerea*. Colonies emerging from tissues will be identified using morphological and molecular methods. Numbers of samples scored as positive for *B. cinerea* will be recorded for each tissue type at each sampling period and related to local weather data in order to identify infection periods and routes of fruit colonization. The dynamics of late-season *B. cinerea* infection will focus on sampling ripe fruit during harvest and assaying for the pathogen present on the interior and exterior of fruit and monitoring the progress of gray mold development on infected fruit. Fruit will be sectioned and plated on agar medium similar to that described above (Dashwood & Fox 1988) and the percentage of fruit infected with *B. cinerea* isolated recorded at each sampling date. Weather data will be recorded from two of WSU's AgWeatherNet stations closest to each sampling site and related to infection frequency in order to determine weather conditions controlling infection events.

2) Resistance of *Botrytis cinerea* to commonly used fungicides

Isolates obtained and stored in pure culture under Objective 1 will be screened for resistance to currently registered and commonly used fungicides in raspberry production in the US-PNW. Conidial germination, germ tube elongation and mycelial growth assays on discriminatory concentrations of technical grade fungicides will be employed as is commonly used to assay fungicide resistance in *B. cinerea* (Leroch et al 2013, Weber 2011). Levels of resistance and frequencies of isolates in each resistance category will be recorded as well as frequencies of cross-resistance to multiple fungicides.

Anticipated Benefits and Information Transfer

This research will address critical gaps in our knowledge of the disease cycle of *Botrytis cinerea* causing Botrytis fruit rot of raspberry in the US-PNW and provide important baseline data on the status of fungicide resistance. The identification of routes of flower and fruit infection will allow more precise and effective timing of fungicide applications allowing producers to move away from calendar-based spray schedules in favor of more biologically-based application schedules. The specific effects of fungicide spray timing will be the focus of future studies and will build on knowledge of the life cycle of the pathogen learned from this research. Improved timing will allow reductions in overall fungicide use, reduced selection for fungicide resistance and reduced fungicide residues in fruit. Knowledge of baseline levels of resistance to each fungicide as well as cross-resistance to multiple fungicides will allow the design of spray schedules that minimize resistance risk and extend the lifespan of currently registered fungicides while maintaining effective disease control.

References

Boyd-Wilson, K., F. Obanor, R.C. Butler, P. Harris-Virgin, G.I. Langford, J.T. Smith and M. Walter. 2013. Sources of *Botrytis cinerea* inoculum for flower infection in blackcurrants in New Zealand. Australasian Plant Pathology 42: 27-32.

Bristow, P.R., R.J. McNicol and B.W. Williamson. 1986. Infection of strawberry flowers by *Botrytis cinerea* and it relevance to grey mould development. Annals of Applied Biology 109: 545-554.

Coyne, D., G. Menzies, C. Burrows and C. MacConnell. 2012. Integrated pest management for raspberries. WSU Whatcom County Extension.

Dashwood, E.P. and R.A. Fox. 1988. Infection of flowers and fruits of red raspberry by *Botrytis cinerea*. Plant Pathology 37: 423-430.

Ellis, M.A., L.V. Madden, S.R. Wright and L.L. Wilson. 2008. Efficacy of pre-harvest fungicide applications and cold storage for post-harvest control of Botrytis fruit rot (gray mold) on red raspberry. Plant Health Progress doi:10.1094/PHP-2008-1015-01-RS

Jarvis, W.R. 1962. The infection of strawberry and raspberry fruits by *Botrytis cinerea* Fr. Annals of Applied Biology 50: 569-575.

Leroch, M., C. Plesken, R.W.S. Weber, F. Kauff, G. Scalliet and M. Hahn. 2013. Gray mold populations in German strawberry fields are resistant to multiple fungicides and dominated by a novel clade closely related to *Botrytis cinerea*. Applied and Environmental Microbiology 79: 159-167.

McNicol, R.J., B. Williamson and A. Dolan. 1985. Infection of red raspberry styles and carpels by *Botrytis cinerea* and its possible role in post-harvest grey mould. Annals of Applied Biology 106: 49-53.

McNicol, R.J., B. Willimason and A. Dolan. 1990. Effects of inoculation, wounding and temperature on post-harvest grey mould (*Botrytis cinerea*) of red raspberry. Journal of Horticultural Science 65: 157-165.

Weber, R.S. 2011. Resistance of *Botrytis cinerea* to multiple fungicides in Northern German small fruit production. Plant Disease 95: 1263-1269.

Williamson, B. and A.J. Hargreaves. 1981. Effects of *Didymella applanata* and *Botrytis cinerea* on axillary buds, lateral shoots and yield of red raspberry. Annals of Applied Biology 97: 55-64.

Williamson, B. and R.J. McNicol. 1986. Pathways of infection of flowers and fruits of red raspberry by *Botrytis cinerea*. Acta Horticulturae 183: 137-141.

Williamson, B., B. Tudzynski, P. Tudzynski and J.A.L. van Kan. 2007. *Botrytis cinerea*: the cause of grey mould disease. Molecular Plant Pathology 8: 561-580.

Budget:

	2015	**2016**
Salaries [1]	11,250	11,700
Time-slip	0	0
Operations (Goods & Services)	5,000	5,000
Travel [2]	1,500	1,500
Meetings [3]	1,500	1,500
Other	0	0
Equipment	0	0
Benefits [4]	3,364	3,498
Total	**$22,614**	**$23,198**

*Budget approved by Jason Croyle at WSU Johnson Hall Business Center

Budget Justification:

[1] 0.25 FTE post-doctoral salary - Dr. Dalphy Harteveld
[2] Weekly trips to field site in Whatcom Co.
[3] Post-doc to attend annual meeting of the American Phytopathological Society
[4] Benefits rate = 29.9%

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:				
Peever	WA Raspberry	21996	03/10/14 to 06/30/15	15	Biology and Control of Botrytis fruit rot of red raspberry
Peever	WA Blueberry	22496	4/28/14 to 06/30/15	15	Biology and Control of Mummy Berry and Botrytis fruit rot of blueberry
Peever	WSCPR	22496	04/01/14 to 03/30/15	15	Biology and Control of Mummy Berry and Botrytis fruit rot of blueberry
Peever	WSCPR	21996	04/01/14 to 03/30/15	15	Biology and Control of Botrytis fruit rot of red raspberry
Peever and Grunwald	Northwest Center for Small Fruits Research	104738	10/1/204 to 09/30/2017	15	Host specificity and gene flow of fungicide resistance alleles among *Botrytis cinerea* populations infecting small fruit in the US Pacific Northwest
Peever	BC Blueberry Council	32638	05/15/2014 to 03/15/2016	10	Fungicide resistance of *Botrytis cinerea* infecting raspberry and blueberry in BC

	Pending:				
Peever	WA Raspberry	22614	03/10/15 to 02/28/16	15	Biology and Control of Botrytis fruit rot of red raspberry (this proposal)
Peever	WA Blueberry	????	04/01/15 to 03/30/16	15	Biology and Control of Mummy Berry and Botrytis fruit rot of blueberry
Peever	WSCPR	????	04/01/15 to 03/30/16	15	Biology and Control of Mummy Berry and Botrytis fruit rot of blueberry
Peever	WSCPR	????	04/01/15 to 03/30/16	15	Biology and Control of Botrytis fruit rot of red raspberry

Project: 13C-3755-5642
Title: Tracking the movement of RBDV in Red Raspberry from pollination to systemic infection using Real-time RT PCR.
Personnel: Patrick P. Moore, Professor, Washington State University Puyallup Research and Extension Center
Kara Lanning, PhD student, WSU Puyallup
Cooperator: Bob Martin, USDA-ARS, Corvallis, OR.

Reporting Period: 2014

Accomplishments:
The time required for Raspberry Bushy Dwarf Virus (RBDV) to infect the raspberry plant and become systemic was determined. It had been speculated that spread of RBDV could be slowed or eliminated by pruning out the floricanes soon after harvest. This study demonstrated that the virus moves very rapidly and this is not an option for RBDV control.

Plants of 23 cultivars in a field planting were virus tested. All 16 of the resistant and 7 susceptible cultivars had at least one plant test virus positive. This indicates that there is at least one resistance breaking strain of RBDV. This has direct implications on breeding for RBDV resistance. At this time, we do not know what effects these different strains have on the plants.

Results
A study was conducted to determine how quickly Raspberry Bushy Dwarf Virus (RBDV) moved within a flowering raspberry plant. Plants of ‘Meeker’, ‘Willamette’ and plants that had tested RBDV positive for three consecutive years were placed in a screenhouse. Bumblebees were introduced at the time of bloom and samples were collected at specified time points. In 2014, sampling started one day after introduction of bumblebees. RBDV was detected in the plant one day after the introduction of the bumblebees and was detected at the base of the floricane by day 3. It had been speculated that spread of RBDV could be slowed or eliminated by pruning out the floricanes soon after harvest. This study demonstrated that the virus moves very rapidly and rapid pruning of fruiting canes is not an option for RBDV control.

Field plants of 16 resistant and 7 susceptible raspberry cultivars were tested for RBDV using ELISA and primers targeting two viral genes. Only two plants (both RBDV resistant cultivars) out of the 49 plants tested were negative for RBDV for all three tests. All cultivars tested positive for at least one plant for at least one test. These results indicate that there are multiple strains of RBDV present and some of these will infect plants that have formerly been resistant to RBDV. The results of the sampling indicate the presence of one or more resistance breaking strains of RBDV in the field plots at WSU Puyallup. We do not know what effects these different strains have on the plants or the origin of these strains.

Project: New **Proposed Duration:** 2 year

Project Title: Evaluation of Raspberry Bushy Dwarf Virus strains

PI: Patrick P. Moore
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Cooperator: Bob Martin
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Year Initiated 2015 **Current Year** 2015 **Terminating Year** 2016

Total Project Request: Year 1 $6,990 Year 2 $1,249 Total $8,239

Other funding sources: None

Description: RBDV resistant raspberry cultivars were identified in 2014 that tested RBDV positive. Raspberry plants were tested using ELISA and primers targeting two viral genes. ELISA and primer results can be used to group the resistance breaking viral strains into three groups. Other tests might result in more or different groups. We do not know what effects these newly discovered resistance breaking strains have. The purpose of this project is to determine the effects of these strains on fruit characteristics. Plants of each viral strain will be grafted onto 'Meeker', 'Chemainus' and 'Willamette' to produce plants of each cultivar with each virus strain. These plants along with virus free plants will be grown in pots through 2015 and allowed to fruit in 2016. Fruit will be weighed, fruit firmness measured and number of drupelets per fruit counted. The effects of each virus strain will be compared with the virus free controls.

One strain of the virus appears to be graft and pollen transmissible, but lacking the virus coat protein. Plants with this strain will be graft inoculated with plants with RBDV with the coat protein to test if there is cross protection that would provide plant resistance by the presence of the partial virus.

Justification and Background: RBDV is a widespread, pollen borne virus with large economic effects. The only control method has been to breed for RBDV resistant cultivars. Studies conducted in 2014 indicated the presence of resistance breaking strains of RBDV. At this time, we do not know what effects these resistance breaking strains have. This study will compare fruit weight, fruit firmness and drupelet number between virus free plants and plants with different strains of RBDV as indications of the severity of the different viral strains. A novel strain of RBDV was detected that appears to lack the coat protein. It is not known if plants infected with one strain of RBDV could be infected with another strain. Plants with the novel strain of the virus will be graft inoculated with other viral strains to determine if the novel strain of the virus could block the other strains from infecting the plant.

Relationship to WRRC Research Priority(s):
This project addresses a first-tier priority and a third-tier priority of the WRRC:

First-Tier: Develop cultivars that are summer bearing, high yielding, winter hardy, machine-harvestable, disease resistant, **virus resistant** and have superior processed fruit quality

Third-Tier: Viruses/crumbly fruit, pollination

Objectives:

1) This project will determine the impact of resistance breaking strains of RBDV on the fruit of selected raspberry cultivars.

2) This project will determine if the presence of a novel strain of RBDV lacking the coat protein will block the other strains from infecting the plant.

Objective 1. Plants of selected raspberry cultivars will be infected with specific strains of RBDV in 2015. These plants will fruit in 2016 and fruit will be evaluated in 2016.

Objective 2 will be accomplished in 2015.

Procedures: This project will take 2 years.
In 2015
Plants with strains of RBDV will graft inoculate Meeker, Chemainus and Willamette.
The strains of RBDV are distinguished by positive or negative results when tested by ELISA for the coat protein, by PCR for the coat protein gene and by PCR for the Polymerase gene.

RBDV strains	ELISA	Coat Protein gene	Polymerase gene
Common strain (D200)	+	+	+
Resistance Breaking strain 1	+	+	+
Resistance Breaking strain 2	+	-	+
Resistance Breaking strain 3	-	-	+

Based on results from 2014, plants that were tested by the three methods will be selected and used to graft inoculate plants of Meeker, Chemainus and Willamette. Meeker and Chemainus are susceptible to the common strain and Willamette is a RBDV resistant standard. After grafting, the plants will be tested to determine if the strains were transmitted to the cultivars. Infected plants will be grown in pots in 2015.

Plants of susceptible and resistant plants that tested positive for resistance breaking strain 3 will be propagated and then graft inoculated by the common strain and resistance breaking strains 1 and 2. The plants that had resistance breaking strain 3 will be tested to determine if other strains of RBDV were transmitted.

In 2016
Plants of Meeker, Chemainus and Willamette that are positive for a virus strain will be placed in separate netted enclosures and bees introduced. Virus free plants will be enclosed in an enclosure and serve as a control. Fruit will be harvested and firmness, fruit weight and drupelet number determined. Fruit of infected plants will be compared to virus free plants.

Anticipated Benefits and Information Transfer:
This project will provide growers with information on the effects of these newly identified strains of RBDV. If there are serious effects of these strains, virus testing procedures may be modified and breeding efforts for RBDV resistance may be modified.

Results of this research will be included in the progress report and at commission and other grower meetings.

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

	2015	2016
Salaries	$0	$0
Time-slip	$5,000	$500
Goods and Services[1]	$1,500	$700
Travel	$0	$0
Benefits 9.8%	$490	$49
Total	$6,990	$1,249

[1] Laboratory supplies and bee hives

Current Support

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	Title of Project
Moore, P.P. and Hoashi-Erhardt	Northwest Center for Small Fruit Research	$32,419	2014-2015	Small Fruit Breeding in the Pacific Northwest
Moore, P.P. and Hoashi-Erhardt	Northwest Center for Small Fruit Research	$34,144	2014-2015	Enhanced Tools for Improving Root Rot Resistance in Red Raspberry
Moore, P.P. and Hoashi-Erhardt	Washington Red Raspberry Commission	$70,000	2014-2015	Red Raspberry Breeding, Genetics and Clone Evaluation
Moore, P.P. and Hoashi-Erhardt	Washington Strawberry Commission	$18,000	2014-2015	Genetic Improvement of Strawberry
Moore, P.P., K.K. Lanning and R.R. Martin	Washington Red Raspberry Commission	$8,750	2014-2015	Tracking the movement of RBDV
Moore, P.P. and Hoashi-Erhardt	Oregon Raspberry and Blackberry Commission	$4,400	2014-2015	Genetic Improvement of Raspberry
Moore, P.P. and Hoashi-Erhardt	Oregon Strawberry Commission	$4,400	2014-2015	Genetic Improvement of Strawberry
Moore, P.P. and Hoashi-Erhardt	Washington State Department of Agriculture	$32,109	2014-2017	Fresh Market Strawberry Pre-Breeding for Repeat Flowering and Powdery Mildew Resistance

Pending Support

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	Title of Project
Moore, P.P. and Hoashi-Erhardt	Washington Red Raspberry Commission	$75,000	2015-2016	Red Raspberry Breeding, Genetics and Clone Evaluation
Moore, P.P., K.K. Lanning and R.R. Martin	Washington Red Raspberry Commission	$8,239	2015-2016	Evaluation of Raspberry Bushy Dwarf Virus strains
Moore, P.P. and Hoashi-Erhardt	Washington Strawberry Commission	$37,000	2015-2016	Genetic Improvement of Strawberry

Washington Red Raspberry Commission
Progress Report Format for 2014 Projects

Project No:

Title: Integration of Factors to Improve Soil Health in Red Raspberry Production

Personnel: Chris Benedict, Colleen Burrows, Eric Gerbrandt, Lisa Wasko DeVetter, Inga Zasada, Jerry Weiland

Reporting Period: 2014

Accomplishments: This project has entered into its third year of treatment implementation. Plant health and growth was monitored through spring and fall primocane diameter measurements, monthly visual inspections, yield estimates (fruit weight over three collections periods, total weight, and average yield), and SPAD (chlorophyll) monitoring in July and August. Soil health measurements included chemical (spring nutrient), physical (bulk density, compaction, infiltration), and biological (*P. penetrans*). Tensiometer controlled irrigation lines and flow meters were re-installed in the spring. A between-row application of composted dairy solids (10 tons/A BR +IR) with and without brassica seed meal (1.0 ton/A IR only) was applied in mid-spring. An additional brassica seed meal rate trial (0.5, 1.0, and 1.5 tons/A) was included at one site. Relationship analysis will determine what (i.e. management, soil, plant) factors are correlated with soil health indicators that may lead to improved management options. Additionally, in collaboration with Dunlap and Zasada (parallel project) samples from these plots have begun analysis of microbial communities present. This the first time this in-depth analysis has been performed in red raspberries.

Results: To date soil nutrient, plant health/growth, estimated yield, water use, soil moisture, bulk density, compaction, infiltration, and SPAD readings have been compiled and analysis has just begun. Soil biological assay results are still being finalized. Tensiometer controlled irrigation lines utilized 44% and 14% (29% average across sites) less water at each site, respectively while maintaining adequate soil moisture levels. Cover crops were well-established at both sites in both the spring and fall. There was significant improvements in all physical soil measurements performed in plots that have received two years of cover cropping. Of note was a significant reduction in bulk density, a significant decrease in water infiltration rates, and a significant reduction in soil compaction in plots that were cover cropped.

Publications: Preliminary results were shared at the Washington red raspberry commission research review in October 2014. Additionally, we are planning to include an article in the February issue of the Whatcom Ag Monthly focused on this project targeted towards producers. Much of outreach materials is located on the WSU Whatcom County Extension website.

2015 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

Continued Project Proposal **Proposed Duration:** 2 years
Project Title: Integration of Factors to Improve Soil Health in Red Raspberry Production

PI: Chris Benedict, WSU Whatcom County Extension | Agriculture Extension Educator | 1000 N. Forest St. Suite 201 | Bellingham, WA, 98225 | (360) 676-6736 | chrisbenedict@wsu.edu

Cooperators: Eric Gerbrandt, Lisa Wasko DeVetter, Inga Zasada, Jerry Weiland, Randy Honcoop Farms and Curt Maberry Farms

Year Initiated2012 Current Year 2015 Terminating Year 2016
Total Project Request: $14,265 Year 1:$5,787 Year 2: $8,478 Year 3: $0
Other funding sources: *None*

Description: Many red raspberry producers have witnessed a reduction in the harvestable productivity of their plantings. Much of this can be attributable to increases in soil borne pathogens and reliance on cultural practices (such as cultivation and lack of introduction of organic matter) that can lead to a decline in soil health. To overcome this decline, producers are relying on increased inputs which have resulted in increased production costs. This project will continue efforts that began in 2012 that includes use of ground covers (small grains and brassicas) and soil amendments (brassica seed meal, composted dairy solids, organic acid) to evaluate their impacts on various soil health parameters (biological, chemical, and physical). Intrinsic in the design of these trials is a long-term viewpoint and the development of an adaptive management strategy as basic knowledge is obtained.

Justification and Background: Raspberry growers have noticed a decrease in the duration of productive plantings, resulting in significant income losses and replant costs. This was documented in a producer survey in 2012 which found that 63% reported a loss in productivity of >20% in the past five years (Benedict, unpublished). Causes of this decline have been attributed to soil borne plant pathogens combined with losses in other biological and physical components of soil. The effectiveness of pre-plant fumigants are short-lived with current use patterns and there are limited during-production management options.

While development of resistant varieties to these pests is the long-term solution, other methods have been tested to manage root rot (*Phytophthora rubi*) and nematodes (*Pratylenchus penetrans*). Other options, such as fallow periods, are not an economically feasible option for many producers and improper management of this fallow period can lead to declines in other soil health parameters (Forge et al., 2000). The use of ground covers to reduce *P. penetrans* populations has had mixed results: reductions have occurred in some studies (Forge et al., 2000), while populations were not significantly reduced in others (MacGuidwin and Layne, 1995). Brassica seed meals have shown potential to reduce *P. rubi* and *P. penetrans* populations pre-plant (Gigot et al., 2013), but have not been extensively tested in established red raspberries. Organic acids have shown promise for promoting root growth/health in blueberries, but have not been extensively tested in red raspberries (Bryla and DeVetter, unpublished).

Physical soil health issues such as reductions in the organic matter fraction can impact a number of other factors such as fertility, water availability, compaction, erosion (Magdoff and van Es, 2000) and lower mineralization of nutrients (Forge and Kenney, 2011). This results in the requirement for increased inputs such as fertilizers and additional tillage activities, perpetuating soil organic matter losses.

We will evaluate the use of a suite of cultural practices in an integrated fashion so that the individual and combined impacts can be measured. This system-based experiment utilizes promising results found in British Columbia (Forge 2012, Forge and Kempler 2009).

Relationship to WRRC Research Priority(s):
Due to the inter-disciplinary scope of this project it is related to many of the priorities including:

#1 priorities

- Soil fumigation techniques and alternatives to control soil pathogens, nematodes, and weeds

#2 priorities

- Understanding soil ecology and soil borne pathogens and their effects on plant health and crop yields.
- Nutrient/Irrigation management

Objective:

1. Evaluate integrated measures to improve soil health including use of ground covers and soil amendments.

Procedures: This project is designed to be ongoing through the lifetime of a raspberry planting and will continue to utilize similar methods to what is described below, but with adaptive management as treatment results and additional tools become available.

1. **Evaluate integrated measures to improve soil health including use of ground covers and soil amendments.**

The trial was initiated in the spring of 2012 consisting of three replications on two commercial farms planted with 'Meeker' raspberries. Initial treatments variables includes: 1.) *Water Use* (Tensiometer vs. Timed Irrigation)[Main-plot]; 2.) *Ground Covers* (No cover vs. Spring Planted (SP) vs. Postharvest planted (PH) vs. perennial ground cover (PG) [site 2 only])[split-plot]; and *Fertility* (Organically derived nutrient source vs. synthetic fertilizers [site 1 only] [split-plot]; spring soil sample driven vs. standard [site 2])[split-split plot]. Based on initial results the *Water Use* and *Fertility* treatments will be eliminated (*Water*) or modified (*Fertility*) to make room for additional amendment treatments.

In the fall of 2014, PH grounds covers were planted at both sites and will overwinter. SP ground covers will be planted by late April (one site only) after terminating PH ground covers. A commercially available brassica seed meal (MustGrow™) is labeled for use in red raspberries and will be applied in mid-spring (1.0 ton/A) alone and in combination with composted dairy solids (10 tons/A). An additional rate trial (0.5, 1.0, and 1.5 ton/A) will be included to evaluate seed meal's potential phytotoxicity and ability to suppress *P. penetrans*. The fertigation of organic acid amendments (five applications throughout the year) will be evaluated and compared to a standard fertility control. Variables measured will include root and cane growth, as well as *P. penetrans* populations.

Soil samples will be taken from each split-split plot in late March and nutrient content analyzed. Soil and root samples will be collected in early fall and population densities of *P. penetrans* and *P. rubi* determined. Physical soil property assessments will include: compaction (penetrometer: pre- and post-harvest), bulk density (post-harvest), and infiltration (pre- and post-harvest). Dormant primocane assessment (diameter) will occur in late winter (Zebarth et al., 1993) and again in late fall. Effects on yield will be estimated via yield component analysis methodologies adapted from cranberry, which includes sampling of average fruit weight at three times throughout the harvest period (Kozak and Madry, 1004; Baumann and Eaton, 1986). Chlorophyll content (SPAD 502Plus, Konica Minolta Sensing, Inc.) of leaves will be used to assess leaf nitrogen content in August (Privè et al., 1997).

In addition to the above mentioned measurements, this venue has created an unique opportunity to look at the soil microbial community under a few select treatments at site 1. A complimentary proposal has been submitted to address this aspect of the research (Zasada, Dunlap, Benedict).

Anticipated Benefits and Information Transfer: Resulting from this work is a better understanding of management practices that will lead to improved soil health. Results will be shared with producers at the annual small fruit commission reviews in November of 2015. Results will also be published in the Whatcom Ag Monthly Newsletter (February 2015 and December 2015) and on the WSU Whatcom County Extension website.

References:

Baumann, T.E., Eaton, G.W. 1986. Competition among berries on the cranberry upright. *J. Amer. Soc. Hort Sci.*, 111 (6): 869-872.

Forge, T.A. 2012. Alternative raspberry field renovation practices and the use of organic amendments: Implications for root diseases and nitrate leaching, 57th Annual North Willamette Horticulture Society Meeting, Canby, OR, USA, January 10-12, 2012, Berry Section.

Forge, T.A. and E. Kenney. 2011. Soil health, organic amendments and alternative practices for renovation of raspberry fields. SAGES Workshop, Abbotsford, CA.

Forge, T.A. and Kempler, C. 2009. "Organic mulches influence population densities of root-lesion nematodes, soil health indicators and root growth of red raspberry.", *Canadian Journal of Plant Pathology, 31*(2), pp. 241-249.

Forge, T.A., R. E. Ingham, D. Kaufman, and J.N. Pinkerton. 2000. Population Growth of Pratylenchus penetrans on Winter Cover Crops Grown in the Pacific Northwest. J. of Nematology. 32: 42-51.

Gigot, J.A., I. A. Zasada, and T. M. Walters. 2013. Integration of brassicaceous seed meals into red raspberry production systems. Applied Soil Ecology 64: 23-31.

Kozak, M. and W. Madry. 2004. Statistical analysis of multiplicative crop yield components and background of yield modeling. *Postepy Nauk Rolniczych*, 5:13-26.

MacGuidwin, A. E., and T. L. Layne. 1995. Response of nematode communities to sudangrass and sorghum-sudangrass hybrids grown as green manure crops. Supplement to the Journal of Nematology 27:609–616.

Magdoff, F and H. van Es. 2000. Building soils for better crops: 2nd Ed. Sustainable Agriculture

Network. 230 pgs.
Neilsen, D. S. Kuchta, T. Forge, B. Zebarth, C. Nichol, and M. Sweeney. 2011. Irrigation and Nitrogen Management. SAGES Workshop, Abbotsford, CA.
Privè, J., J.A. Sullivan, and J.T.A. Proctor. 1997. Seasonal changes in net carbon dioxide exchange rates of Autum Bliss, a primocane-fruiting red raspberry (Rubus idaeus L.). Can. J. of Plant Sci. 77: 427-431.
Zebarth, B.J., S. Freyman, and C.G. Kowalenko. 1993. Effect of ground covers and tillage between raspberry rows on selected soil physical and chemical parameters and crop response. Can. J. Soil Sci. 73: 481-488.

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

	2015	**2-Year Total ('14-'15)**
Salaries[1/]	$509	$998
Time-Slip	$2160	$4590
Operations (goods & services)	$4570	$5780
Travel[2/]	$848	$1695
Meetings	$0	$0
Other	$0	$0
Equipment[3/]	$0	$400
Benefits[4/]	$391	$801
Total	**$8478**	**$14265**

2015 Budget Justification
[1/] One WSU Whatcom County Extension Personnel at 0.01% FTE ($509); One WSU Whatcom County Extension timeslip (144 hr. @ 15 hr.) ($2,160)
[2/] Travel to and from research sites, 1500 miles at $0.56/mile ($840)
[4/]Employee benefits for Extension personnel (35.59% $181) and timeslip (9.7%)($210).

CURRENT & PENDING SUPPORT

Name: Chris Benedict

Instructions:
Who completes this template: Each project director/principal investigator (PD/PI) and other senior personnel that the Request for Applications (RFA) specifies
How this template is completed:

- Record information for active and pending projects, including this proposal.
- All current efforts to which PD/PI(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.
- Provide analogous information for all proposed work which is being considered by, or which will be submitted in the near future to, other possible sponsors, including other USDA programs.
- For concurrent projects, the percent of time committed must not exceed 100%.

Note: Concurrent submission of a proposal to other organizations will not prejudice its review by CSREES.

NAME (List/PD #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Active:				
Benedict, C., J. Shaw, L. Bodeminster	WA Dairy Products Commission	$48,417	4/1/14-12/31/15	1%	Evaluation of Narrow Buffers for Narrow Agricultural Waterways.
Benedict, C. Burrows, C L. Wasko DeVetter	WA Red Raspberry Commission	$5,786	1/1/14-12/31/14	1%	Integration of Factors to Improve Soil Health in Red Raspberry Production.
Murphy, K Baik, B Benedict, C. Desta, K Dillon, M. Epstein, L. Goldberger, J. Machado, S. Maughan, J. Matanguihan, J. Petri, S. Reeve, J. Van Horn, M.	USDA-NIFA	$1,236,000	1/1/13-12/31/16	5%	Developing adapted varieties and optimal management practices for quinoa in diverse environments
Collins, D. Ostrom, M. Benedict, C. Garcia-Pabon, J. Busboom, J. Flores, M. Heitsuman, M.	USDA BFRDP	$749,999	8/1/12-7/31/15	10%	Cultivating New Generation and Immigrant Farmers in Washington State
Reganold, J.P., C. Benedict, D. Crowder, K. Murphy, K. Painter	WSU CAHNRS ERI Program	$18,950	1/1/14 – 12/31/15	1%	Introducing Organic Quinoa Production Systems in the Palouse.
Benedict, C.	PNW Potato Consortium	$15,000	1/1/14 – 12/31/15	1%	Management of potato viruses in the

Karasev, A. Inglis, D. McMoran, D.					Pacific Northwest
Collins, D Benedict, C Corbin, A Bary, A Cogger, C	USDA-SARE	$249,949	10/1/14-9/30/17	1%	Increasing adoption of reduced tillage strategies on organic vegetable farms in the maritime Northwest
D. Hayes (PD), A. Wszelaki, J. DeBruyn, D. Inglis, C. Miles, J. Goldberger, T. Marsh, M. Flury, J. Cowan, M. Fly, S. Schexnayder, C. Benedict, E. Belasco, M. Velandia	USDA-NIFA	$4,884,785	10/1/14-9/30/19	30%	Adoptability and Long-Term Effects of Biodegradable Plastic Mulches for Specialty Crop Production
DeJong, W., Charkowski, A., Gray, S., and 26 other PIs	USDA-NIFA	$8,400,000	10/1/14-9/30/19	20%	Biological and economic impacts of emerging potato tuber necrotic viruses and the development of comprehensive and sustainable management practices.
Inglis, D. Benedict, C. McMoran, D.	WSDA-SCBG	$203,802	10/1/14 – 9/30/17	20%	Proactive Approaches to Protect Western Washington Specialty Potatoes Against New Strains of *Potato virus Y*
Pending: Reganold, J, Carpenter-Boggs, L. Benedict, C. et al.	Emerging Research Issues for Washington Agriculture	$40,136	2/2014 – 1/2015	1%	Introducing Organic Quinoa Production Systems in the Palouse
Benedict, C. Shaw, J. Boedminster, L. Helfield, J.	WA Dairy Product Commission	$31,858	1/1/15-12/31/15	1%	Evaluation of Narrow Buffers for Narrow Agricultural Waterways
Haggith, D. Likkel, F. Benedict, C	WA Dairy Product Commission	$15,131	1/1/15-12/31/15	1%	Estimating the Impact of Soil Compaction on Grassland Yield and Soil Infiltration in Western Washington
Kerr, S. Fredricks, G. Collins, D. Adams-Progar, A. Chaney, M. Fransen, S. Harrison, J. Benedict, C.	WA Dairy Product Commission	$25,000	1/1/15-12/31/15	1%	Moving Towards Best Pasture Management Practices
Wasko DeVetter, L. Rudolph, R. Mazzola, M. Zasada, I. Benedict, C. Jones, S.	Northwest Agricultural Research Foundation	$7,032	1/1/15-12/31/17	1%	Impacts of Alleyway Cover Crops on Soil Quality and Plant Competition in Established Red Raspberry
Wasko DeVetter, L. Rudolph, R. Mazzola, M. Benedict, C.	WA Red Raspberry Commission	$7,032	1/1/15-12/31/16	1%	Impacts of Alleyway Cover Crops on Soil Quality and Plant Competition in Established Red Raspberry

This proposal: Benedict, C. Burrows, C L. Wasko DeVetter	WA Red Raspberry Commission	$8478	1/1/15 – 12/31/15	1%	Integration of Factors to Improve Soil Health in Red Raspberry Production

Washington Red Raspberry Commission
Progress Report Format for 2014 Projects

Project No: ?

Title: Incidence and Detection of *Verticillium dahliae* in Red Raspberry Production Fields

Personnel: Jerry Weiland, Chris Benedict

Reporting Period: 2014

Accomplishments:

- We have sampled 50 diseased sites and 15 healthy sites in WA red raspberry production fields. Once analyses are complete, this project will determine how common *Verticillium dahliae* is in the industry, whether it is associated with disease, and establish inoculum levels associated with damage. If the pathogen is widespread and associated with disease, further funding may be justified to explore disease control measures.
- We have tested and compared the sensitivity of two detection methods for *V. dahliae*. Preliminary results indicate that the DNA-based method of detecting *V. dahliae* is more sensitive than the culture-based detection method. This is significant in that diagnostic laboratories use different methods and may therefore give conflicting results on the presence of the pathogen. These results will help establish which method is the most reliable.
- In addition to *V. dahliae*, we have isolated a number of other pathogens from plants in diseased sites including *Pratylenchus penetrans*, *Phytophthora rubi*, and *Alternaria* and *Fusarium* species. This is significant in that it confirms that *P. rubi* can also cause wilt symptoms in late summer and identifies other potential pathogens (*Alternaria* and *Fusarium* species) that may also be causing disease.
- This project will contribute information about the importance and detection of *V. dahliae*, as well as its occurrence with other pathogens in disease sites. This information will be new to both science and industry.

Results:

- The culture-based detection method did not detect *V. dahliae* very often in 2013. Although 2014 samples are still being assayed by the culture method, we are already detecting *V. dahliae* more frequently, so we expect to add a number of detection sites to last year's survey. Preliminary results indicate that the DNA-based method is more sensitive at detecting *V. dahliae* than the culture-based method. We expect this will further increase the number of sites from which *V. dahliae* was detected in both years. However, we still have a large number of samples from 2013 and 2014 that need to be processed. Once analyses are complete, we will have a much better understanding about the frequency and damage potential of *V. dahliae* to red raspberries.
- Symptom expression was very different this year. Compared to 2013, we rarely found wilted canes in late summer, so we concentrated more on sampling fields where plants were stunted, off-color, or otherwise looked unhealthy.
- In addition to *V. dahliae*, *Phytophthora rubi*, *Pratylenchus penetrans*, and both *Alternaria* and *Fusarium* species were isolated from plants in diseased sites.

Publications:

Weiland, J. E. 2014. *Verticillium* - Is it a problem in red raspberries? Horticulture Growers' Short Course 2014 Proceedings. January 30 - February 1, 2014. Abbotsford, BC, CAN.

Weiland, J. 2013. An aversion to *Verticillium*: With proper attention, verticillium wilt disease can be managed. Digger. 57 (2): 33-36.

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

2015 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

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

Project Title: Fungicide Sensitivity of *Phytophthora rubi* from Washington

PI: Jerry Weiland
Organization: USDA-ARS
Title: Research Plant Pathologist
Phone: (541) 738-4062
Email: weilandj@onid.orst.edu
Address: 3420 NW Orchard Ave
Address 2:
City/State/Zip: Corvallis/OR/97330

Co-PI:
Organization:
Title:
Phone:
Email:
Address:
Address 2:
City/State/Zip:

Cooperators: Inga Zasada (USDA-ARS), Chris Benedict (WSU)

Year Initiated 2015 Current Year 2015 Terminating Year 2016

Total Project Request: Year 1 $5265 Year 2 $5265 Year 3 $NA

Other funding sources:
Agency Name: Oregon Raspberry and Blackberry Commission
Amt. Requested: $2633/year for two years
Notes: To conduct fungicide sensitivity on 25 Oregon *Phytophthora rubi* isolates.

Description: The objective of this study is to determine whether *Phytophthora rubi* isolates from Washington have resistance to three commonly-used fungicides by the red raspberry industry. The specific outcomes are: 1) determine whether fungicide resistance exists in Washington *P. rubi* isolates; 2) establish the baseline fungicide sensitivity of Washington *P. rubi* isolates to determine whether fungicide resistance is developing in the future; and, 3) evaluate *P. rubi* for sensitivity to new fungicide chemistries.

Justification and Background: (400 words maximum)
Phytophthora rubi, causing root rot, is the most devastating disease of red raspberry plants in the Pacific Northwest. Fungicides, such as mefenoxam (Ridomil Gold, Subdue MAXX), fosetyl-al (Aliette), and phosphorous acid derivatives (Agri-Fos, Alude) are one disease control strategy that can be used to manage this disease. However, one of the risks of relying on fungicides to control Phytophthora root rot is the development of resistance in the pathogen to the most commonly-used fungicides. If fungicide resistance develops, disease control may be compromised. To date, there has been no large scale evaluation to determine whether fungicide resistance exists among *P. rubi* isolates of the Pacific Northwest. One recent study by Stewart et al (in press) only tested 4 isolates each from Washington and Oregon and 5 isolates from California against mefenoxam, but not against other fungicides used to control Phytophthora root rot. A broader survey is needed in order to more fully evaluate whether fungicide resistance exists among *P. rubi* isolates in the region and to establish the baseline sensitivity of *P. rubi* to the most commonly-used fungicides. This baseline can then be used to determine whether new pathogen isolates collected in the future are becoming resistant to fungicides.

This project will also be conducted in Oregon on 25 *P. rubi* isolates (due to the smaller size of the industry). No comparable project is planned for Idaho (no funding available) or British Columbia (too difficult to get *P. rubi* isolates across national border).

Relationship to WRRC Research Priority(s):
This project meets two research priorities:
#1 priority: Soil fumigation techniques and alternatives to control soil pathogens, nematodes, and weeds.
#2 priority: Understanding soil ecology and soilborne pathogens and their effects on plant health and crop yields.

Objectives:

- Determine sensitivity of 50 Washington *P. rubi* isolates to mefenoxam, fosetyl-Al, and phosphorous acid.
- Determine sensitivity of 20 Washington *P. rubi* isolates to newer fungicide chemistries such as fluopicolide and cyazofamid.
- Both objectives will be addressed this funding year.

Procedures: (400 words maximum)
Due to the large number of isolates this project is expected to take two years to complete. The budget of $5265 covers research for 25 isolates in 2015. Funds will be requested in 2016 to cover the remaining 25 isolates.

2015: Up to 5 diseased plants will be collected from at least 10 different production fields in the spring and *P. rubi* will be isolated from canes according to methods developed by Stewart et al. (in press). If more isolates are needed to reach the target of 25 isolates, additional plants will be collected in fall. The fungicide sensitivity of the isolates will be tested in petri plates containing different concentrations of each fungicide (Stewart et al. in press, Weiland et al. 2014). The concentration of fungicide that reduces the growth of each isolate will be used to establish fungicide sensitivity. For example, an isolate that has reduced growth at 1 parts per million (ppm) is more sensitive to a fungicide than an isolate that has reduced growth at 100 ppm.

We will test all 25 isolates against three fungicides used for *P. rubi* control: mefenoxam, fosetyl-Al, and phosphorous acid. If any resistant isolates are found, we will test these for sensitivity to newer fungicides with different modes of action such as fluopicolide and cyazofamid. Otherwise, we will then test a representative subset of 10 isolates against the newer fungicide chemistries.

2016: Repeat of 2015 procedures with 25 isolates obtained from 10 different production fields.

Anticipated Benefits and Information Transfer: (100 words maximum)
Results will indicate if *P. rubi* has developed fungicide resistance has developed to mefenoxam, fosetyl-Al, and phosphorous acid. Baseline sensitivity of *P. rubi* to each fungicide will be established and can be used in the future to evaluate whether fungicide resistance is developing. Finally, results will determine if *P. rubi* is sensitive to newer fungicide chemistries - this will help in case fungicide resistance develops to currently-used fungicides and newer chemistries need to be deployed.

Research results will be presented to red raspberry growers at meetings (Small Fruit Conference, Lynden) and communicated to the Washington Red Raspberry Commission, Peerbolt Crop Management, and Whatcom County Extension for inclusion in their newsletters.

References:
Stewart, J. E., Kroese, D., Tabima, J. F., Larsen, M. M., Fieland, V. J., Press, C. M., Zasada, I.

A., and Grünwald, N. J. XXXX. Pathogenicity, fungicide resistance, and genetic variability of *Phytophthora rubi* isolates collected from raspberry (*Rubus idaeus*) in the Western United States. Plant Dis. XX: in press.

Weiland, J. E., Santamaria, L., and Grünwald, N. J. 2014. Sensitivity of *Pythium irregulare*, *P. sylvaticum*, and *P. ultimum* from forest nurseries to mefenoxam and fosetyl-Al, and control of Pythium damping-off. Plant Dis.98:937-942.

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

	2015	**2016**	**2017**
Salaries[1/]	$ 2800	$ 2800	$
Time-Slip	$ 0	$ 0	$
Operations (goods & services)	$ 2000	$ 2000	$
Travel[2/]	$ 0	$ 0	$
Meetings	$ 0	$ 0	$
Other	$ 0	$ 0	$
Equipment[3/]	$ 0	$ 0	$
Benefits[4/]	$ 465	$ 465	$
Total	**$ 5265**	**$ 5265**	**$**

Budget Justification

[1/]One USDA laboratory technician at 0.07 FTE.

[2/] Travel and Meetings provided in kind from Weiland's USDA-ARS CRIS funds.

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

[4/] Benefits USDA laboratory technician (16.6%).

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:				
Grunwald, Weiland, and Scagel	Floriculture and Nursery Research Initiative	175,000	2013-2015	10	Improving plant health for nursery production in the Pacific Northwest
Weiland and Scagel	Northwest Nursery Crop Research Center	29,411	2014-2017	5	Evaluating the impact of root rot pathogens on nursery crop health
Weiland and Benedict	Washington Red Raspberry Commission	12,000	2014-2015	5	Incidence and detection of Verticillium dahliae in red raspberry production fields
Zasada, Weiland, DeVetter, Walters, and Benedict	Northwest Center for Small Fruit Research	28,517	2014-2016	5	Raspberry root removal: eliminating soilborne pathogen preplant inoculum to improve disease management
Weiland	J.F. Schmidt Charitable Foundation	5,000	2015	5	Characterization of Verticillium dahliae isolates from Oregon shade tree nurseries
	Pending:				
Weiland, Benedict, and Zasada	Oregon Raspberry and Blackberry Comission	2,633	2015	5	Fungicide sensitivity of Phytophthora rubi from Oregon

2015 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

Project Title: Evaluation of Humic Acid Amendments in Promoting Root Health and Productivity in Red Raspberry

PI: David Bryla
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Co-PI: Lisa DeVetter
Organization: WSU
Title: Assistant Professor
Phone: 360-848-6124
Email: lisa.devetter@wsu.edu
Address: WSU NWREC
Address 2: 16650 State Route 536
City/State/Zip: Mt. Vernon, WA 98273

Cooperator: Chris Benedict, WSU Whatcom County Extension

Year Initiated 2015 **Current Year** 2015 **Terminating Year** 2016

Total Project Request: **Year 1 $6,630** **Year 2 $6,630** **Year 3 $**

Other funding sources: None

Description:

A number of berry growers in the Pacific Northwest are using humic acids in addition to fertilizers in an attempt to increase production. We recently evaluated humic acids in young plantings of blueberry and raspberry and discovered that a fertilizer program with humic acids produced more plant growth during establishment than conventional fertilizer programs. The objective of the proposed project is to continue this promising work and evaluate the effects of humic acids on yield and fruit quality in red raspberry. Treatments will include commercial humic acid blends incorporated into conventional fertilizer programs. Specific measurements will include cane and root growth, yield, fruit quality (berry size, firmness, Brix, titratable acidity), leaf nutrient status, soil chemical, physical, and biological properties (pH, nutrients, organic matter content, infiltration, bulk density, water holding capacity, and soil microbial activity), and incidence of *Phytophthora* root rot. This information will help growers and others servicing the needs of the industry to determine whether humic acids are a beneficial addition to nutrient management in red raspberry.

Justification and Background:

More and more growers in are using humic acids in berry crops. Humic acids, which also referred to sometimes as organic acids, are commonly used as a soil supplement in agriculture and work best when applied with fertilizers. Most are manufactured from leonardite, a mined coal-like substance formed from decomposition of plant and animal residues. Humic acids increase the availability of soil nutrients and, as a result, are capable of stimulating plant growth

(Clapp et al., 2001). Humic acids may also improve soil water retention and promote beneficial microbial activity (MacCarthy, 2001).

So far, the majority of research on humic acids has been done on annual crops. Recently, we discovered that application of humic acids also increased plant growth during the first two years after planting in blueberry (Figure 1). The effect of humic acids on root growth were particularly apparent and resulted in 46% to 75% greater root dry weights than conventional fertigation, granular fertilizers, slow-release fertilizers, or a control treatment that lacked humic acids but contained exactly the same nutrients as the humic acid treatment (Bryla and Vargas, 2014).

Figure 1. Humic acids increased shoot growth of young blueberry plants by 11% and root growth by nearly 50%.

Last summer, we conducted a preliminary trial and found that humic acids also improve growth in red raspberry. The trial was done in Mt. Vernon on 'Meeker' and 'Malahat'. 'Malahat' was selected due to its high susceptibility to root rot. Plants were grown with a commercial humic acids product and compared to untreated plants grown with fertilizer only. The leaves of both cultivars were greener during the first few weeks after planting when the humic acids were applied, and by the end of the summer, the plants were larger (Table 1). Humic acids appear to be beneficial during establishment of raspberry. However, we have no scientific information to date on the effects of humic acids in mature, fully-productive plants. Therefore, the plan for the proposed study is to continue applying humic acids to the plants and determine if it has any effect on yield or fruit quality in red raspberry. We will also test it in a mature commercial raspberry planting in Whatcom County, in cooperation with Chris Benedict, as well as in a greenhouse in new plants grown in containers filled with a soil from Puyallup that is heavily infested with *Phytopthora*.

Table 1. Plant height of two red raspberry cultivars grown with or without humic acids during the first year after planting (2014).

	Plant height (ft.)^z	
Treatment	Aug. 4	Sept. 9
Cultivar		
Meeker	1.7	3.7
Malahat	1.0	2.5
Difference	0.7**	1.2**
Humic acids		
With	1.5	3.3
Without	1.1	2.9
Difference	0.4*	0.4†
Interaction		
Cultivar × humic acids	NS	NS

^{z}Plant height was measured from the soil surface to the apical meristem of the tallest primocane.
$^{\dagger,*,**}P \leq 0.10$, 0.05, and 0.01, respectively. NS = nonsignificant.

Relationship to WRRC Research Priority(s):

The project will address two second-level priorities, including 1) *nutrient management* and 2) *understanding soil ecology and soil borne pathogens and their effects on plant health and crop yields*.

Objectives:

The following objectives will be addressed for two growing seasons (2015–2016):

1. Evaluate the effects of humic acids on yield and fruit quality (berry size, firmness, Brix, titratable acidity).
2. Determine how humic acids affect the soil conditions (pH, nutrients, organic matter content, bulk density, infiltration, water holding capacity, and soil microbial activity).
3. Ascertain if humic acids help reduce the incidence of *Phytophthora* root rot.

Procedures:

Continuation of current field study. A new planting was established in May 2014 at the WSU Research Center in Mt. Vernon. Treatments include 'Meeker' and 'Malahat' grown with or without humic acids. The treatments are arranged in a randomized complete block design with five replicates and six plants per treatment plot. One plant per plot was harvested destructively in October to measure root and shoot dry weights. The remaining plants will be trellised and trained this winter. Fruit will be hand-harvested and weighed, and subsampled for berry weight, Brix, and titratable acidity (Liu et al., 2014). Leaf samples will be collected each August and analyzed for nutrients (Gavlak et al., 2005). Soil samples will be collected each fall and analyzed for extractable nutrients (Mehlich, 1984), organic matter content (Schulte and Hopkins, 1996), NO_3- and NH_4-N (Dahnke, 1990), and soil pH and EC (McLean, 1982). Water infiltration will be measured using a single ring falling-head procedure (Dane and Hopmans, 2002). Bulk density will be measured on cores collected using a hammer-driven core sampler (Grossman and Reinsch, 2002). The cores will also be measured for water holding capacity (Dane and Hopmans, 2002) and incubated to determine soil microbial activity (Yuste et al., 2007).

Testing humic acids in an established planting. A 4-year-old field of 'Meeker' raspberry will be treated with or without humic acids in Lynden, WA. Treatments will be arranged in a completely randomized design with five replicates of one row each. Fruit will be machine-harvested, and treatment effects on yield, fruit quality, leaf nutrients, and soil conditions will be measured using the same procedures as described above.

Evaluate effects of humic acids on root rot. Soil will be collected from the WSU Research & Extension Center in Puyallup, WA. The field has been planted with raspberry breeding trials for many years and is known to be heavily infested with *Phytophthora rubi*. Seven cultivars with a wide range of resistance to *Phytophthora* (Valenezuela-Estrada et al., 2012) will be planted in pots filled with the infested soil and grown in a greenhouse in Mt. Vernon. The cultivars will include: 'Summit', 'Cascade Bounty', and 'Cascade Delight' (high resistance), 'Meeker' and 'Tulameen' (moderate resistance); and 'Malahat' and 'Saanich' (low resistance). Six replicates of each will be treated with or without humic acids for 3 months and evaluated for shoot growth, root health, root and shoot biomass, and soil and foliar nutrients, and plant survival.

Anticipated Benefits and Information Transfer:

This study will determine the potential benefits of using humic acids on fruit production in red raspberry. A total of 72.5 million pounds of raspberries were produced in Washington in 2014. If applying humic acids increases yield by even 5% at that level of production (which is not unreasonable, given our findings during establishment), this could result in more than a $2 million increase in value each year.

The results will be presented at field days and grower meetings each year, and published in annual reports, newsletters, extension publications, and peer-reviewed journal articles upon completion of the study.

References:

Bryla, D.R. and O. Vargas. 2014. Nitrogen fertilizer practices for rapid establishment of highbush blueberry: a review of six years of research. Acta Hort. 1017:415-421.

Clapp, C.E, Y. Chen, M.H.B. Hayes, and H.H. Cheng. 2001. Plant growth promoting activity of humic acids substances, p. 243–255. In: R.S. Swift and K.M. Sparks (eds.). Understanding and managing organic matter in soils, sediments, and waters. Intl. Humic Sci. Soc., Madison, WI.

Dahnke, W.C. 1990. Testing soils for available nitrogen, p. 120–140. In: R.L. Westerman (ed.). Soil testing and plant analysis. Soil Sci. Soc. Amer. Book Ser. 3. Soil Sci. Soc. Amer., Madison, WI.

Dane, J.H. and J.W. Hopmans. 2002. Water retention and storage, p. 671−720. In: Dane, J.H. and G.C. Topp (eds.) Methods of soil analysis. Part 4. Physical methods. Soil Sci. Soc. Amer., Inc., Madison, WI.

Gavlak, R., D. Horneck, and R.O. Miller. 2005. Soil, plant, and water reference methods for the western region, 3rd ed. Soil Plant Anal. Council, Inc. <http://www.spcouncil.com>

Grossman, R.B. and T.G. Reinsch. 2002. Bulk density and linear extensibility, p. 201−228. In Dane, J.H. and G.C. Topp (eds.) Methods of Soil Analysis. Part 4. Physical Methods. Soil Sci. Soc. Amer., Inc., Madison, WI.

Liu et al., 2014

MacCarthy, P. 2001. The principles of humic substances: an introduction to the first principle, p. 19–30. In: E.A. Ghabbour and G. Davis (eds.). Humic substances—structures, models and functions. Royal Soc. Chem., Cambridge.

McLean, E.O. 1982. Soil pH and lime requirement. p.199–223. In: A.L. Page et al. (eds.). Methods of soil analysis: Part 2. Agron. Monogr. 9. 2nd ed. ASA and SSSA, Madison, WI.

Mehlich, A. 1984. Mehlich-3 soil test extractant: A modification of Mehlich-2 extractant. Commun. Soil Sci. Plant Anal. 15:1409–1416.

Schulte, E.E. and B.G. Hopkins. 1996. Estimation of soil organic matter by weight loss-on-ignition, p. 21–32. In: F.R. Magdoff, M.A. Tabatabai, and E.A. Hanlon, Jr. (eds.). Soil organic matter: analysis and interpretation. Spec. pub. 46. SSSA, Madison, WI.

Valenzuela-Estrada, L.R., D.R. Bryla, W.K. Hoashi-Erhardt, P.P. Moore, and T.A. Forge. 2012. Root traits associated with phytophthora root rot resistance in red raspberry. Acta Hort. 946:283−287.

Yuste, J.C., D.D. Baldocchi, A. Gershenson, A. Goldstein, L. Misson, and S. Wong. 2007. Microbial soil respiration and its dependency on carbon inputs, soil temperature and moisture. Global Change Biol. 13:1–18.

Budget:

	2015	2016	2017
Salaries	$	$	$
Time-Slip[1/]	$3,300	$3,300	$
Operations (goods & services)[2/]	$1,250	$1,250	$
Travel[3/]	$1,500	$1,500	$
Meetings[4/]	$ 250	$ 250	$
Other	$	$	$
Equipment	$	$	$
Benefits[1/]	$ 330	$ 330	$
Total	**$6,630**	**$6,630**	**$**

Budget Justification:

[1/]Undergraduate students will assist with data collection and processing of root samples. One student will be hired for 3 months each summer (2015-2016) and will work 25 h/wk at a salary of $11/h. The fringe benefit rate for undergraduate students is 10%.

[2/]Funding is requested to help cover the cost of field and laboratory supplies.

[3/]Travel is requested for the PI to take three trips to the field site each year ($500/trip).

[4/]Funding is requested for the PI to present the results of the study at the Washington Small Fruit Conference each year ($250/trip).

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:				
Bryla	NCSFR	$105,000	10/1/13–9/30/16	10%	Nitrogen-enriched composts for highbush blueberry
Valenzuela & Bryla	NCSFR	$ 96,441	10/1/13–9/30/16	5%	Potential benefits of humic acids on yield and fruit quality in highbush blueberry
Bryla	OBC/WBC	$ 13,000	1/1/14–12/31/14	10%	Practices for reducing heat-related fruit damage in highbush blueberry
	Pending:				
Bryla	Fluid Fertilizer Foundation	$ 20,000	4/1/15–3/31/16	10%	Soil acidification for blueberry using nitrogen and potassium fertilizers
Bryla & DeVetter	WRRC	$ 13,260	4/1/15–3/31/16	10%	Evaluation of humic acid amendments in promoting root health and productivity in red raspberry

Project No: Contract No. 1

Title: Evaluating soil fumigation alternatives in Washington raspberry fields.

Personnel: Thomas Walters, Walters Ag Research (PI); Inga Zasada, USDA-ARS HCRL (Co-PI)

Reporting Period: 2014

Accomplishments:

- We established an evaluation block to compare an old idea (fumigation with Vapam) with the current standard (Telone C-35 fumigation) and with a non-fumigated check. This trial was established in a field with significant root lesion nematode populations.
- We established a trial of a new soil fumigant, Dominus, in red raspberry. We brought product representatives to Lynden to meet with growers, and two growers expressed interest. We collected prefumigation samples from both of these growers, establishing root lesion nematode numbers in the potential trial areas. One grower decided not to persue the trial in this field due to logistical considerations, but a trial was established with the second grower, Maberry Packing. We coordinated trial layout and field fumigation with the manufacturer, the grower and Trident. We applied the product with the grower's application rig, and have collected the first postfumigation samples for this project.
- We brought a second new idea for fumigation to Western Washington raspberry growers: incorporation of matam sodium with a rotary spader. We coordinated a Lynden visit with a representative from Imants, a Dutch manufacturer of rotary spaders. This visit led to increased interest in rotary spaders on the part of Washington Tractor, who subsequently carried several. It also prompted one raspberry grower, Maberry Packing, to explore the use of a rotary spader for incorporation following application. Although the spader was unavailable on the day this trial was to be established, the grower continues to be interested, and we hope to establish this trial soon.
- We worked with a grower (Rob Dhaliwal) interested in trying a fallow year and Brassica cover crop in place of fumigation. We documented that root lesion nematode populations were moderate in the old crop, and that some nematodes remained on the winter cover crop following. We found that numbers were reduced following incorporation of the Brassica cover crop.
- Hosted a field day for fumigation alternatives in Lynden, September 17, 2014.
- Worked with Trident Agricultural products to help develop their bed fumigator.

Results:

- Prefume samples showed mean population densities in the Dominus/Vapam/C-35 trial plots of 559-1474 *P. penetrans*/g root; fairly high and uniform pressure.
- After Brassica cover crop incorporation, soil at Rob Dhaliwal's had only 24 *P. penetrans*/ g soil, and 15 *P. penetrans*/g root, low levels.

Publications:

- None yet, this project has just started.

2014 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

Second Year Project Proposal **Proposed Duration:** Year 2 of 3

Project Title: Evaluating soil fumigation alternatives in Washington raspberry fields.

PI: Thomas Walters
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Co-PI: Inga Zasada
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Cooperators: Rob Dhaliwal, Jon Maberry, possibly others

Year Initiated 2014 **Current Year 2015** **Terminating Year 2016**

Total Project Request: **Year 1 $ 8,095** **Year 2 $ 8,643** **Year 3 $ 8,805**

Other funding sources: None, but this project builds upon a previous USDA-RAMP grant to Walters, Zasada and others.

Description: We will help growers interested in alternative fumigation practices establish trials of these on their farms, we will help them evaluate the strengths and weaknesses of these practices, and we will present results of these trials to the raspberry industry. These practices may include, but are not limited to: bed fumigation, use of metam products with a rotary spader and incorporation of mustard cover crops or seed meals.

Our objective is to identify soil fumigation practices that are effective, economical and manageable for growers. Washington growers must comply with buffer zones, fumigant management plans and other features of new labels as a result of EPA's reregistration of metam and cloropicrin. The process is underway for Telone, as well.

The outcome we seek is a wider understanding, shared among industry members, of the merits, costs and limitations of alternative fumigation practices. We envision that growers will not limit their options to the current standard of broadcast, nontarped deep shank injection with Telone C-17 or C-35 for every field to be replanted. Instead, they will be able to knowledgably choose from several options, appropriate to the needs of their particular field and operation.

Justification and Background:
We will address the issue of a lack of fumigation options for raspberry growers in Washington

State. In spite of enormous changes in fumigant labels and their requirements, fumigation practices have changed very little so far. Growers break up fields into smaller sections for fumigation to reduce buffer zone size, but continue to use the same products, rates and application methods.

The practices used are not entirely successful. Nontarped deep shank fumigation does not allow much fumigant to accumulate in the upper part of the soil profile. We've documented root lesion nematode survival in fields fumigated this way: in four of six fields, we found substantial populations of *P. penetrans* one year after fumigation. Broadcast deep-shanked applications are also sometimes weak in weed control, for the same reason.

Trident Ag Products recently developed a bed fumigation apparatus in 2014, which we hope to trial in 2015. Although our earlier bed fumigation trials indicated that tarped bed fumigation was at least as effective as nontarped broadcast fumigation, some growers wanted a shaper better suited to their use. Trident's shaper produces much deeper and wider beds, more similar to those commonly in use in the industry.

Some growers are interested in Metam application incorporated with a rotary spader and power roller. A specialty equipment manufacturer, Imants, makes an applicator for this purpose. Rotary spader application of metam has been highly successful in strawberry nurseries in Spain. It is now considered a preferred method of soil fumigation for that crop (Garcia-Sinovas et al, 2008), although it was not successful before the use of the rotary spader to incorporate the Metam. In 2014, we coordinated a visit of Imants representatives to Whatcom County. While the equipment was not available for the 2014 fumigation trials, we expect that it will be available in 2015.

We initiated the first trial of a new soil fumigant, Dominus, in raspberry in 2014. We will follow the progress of this trial in 2015, and can establish additional trials if growers are interested.

Non-chemical alternatives to soil fumigation, such as Brassica cover crops, incorporation of mustard seed meals and Anarobic soil disinfestation, have been explored by numerous researchers and growers, but have not yet found widespread use by raspberry growers. These practices may be adequate for fields without large disease or nematode populations.

Relationship to WRRC Research Priority(s): This project directly addresses a #1 priority of the WRRC, "Soil fumigation techniques and alternatives to control pathogens, nematodes and weeds".

Objectives:
Our overall objective is to identify soil fumigation practices that are effective, economical and manageable for growers. This year, we will:

- Follow up on established trials of Metam, Dominus, and fallow year/brassica cover crop.
- Help growers establish fumigation trials in their fields, by researching potential new practices, planning trial layouts and sampling timelines, and coordinating with custom fumigators.
- Host a fumigation-oriented field day.

Procedures:
Established trials. Root nematode populations on cover crop in the Metam and Dominus trials has already been collected. Soil nematode populations will be assessed at planting in these trials, and soil and root populations will be assessed in the fall. Weed pressures will be recorded in the Metam trial, the Dominus trial, and the Brassica cover crop/fallow year trial several times March through June. Disease and plant vigor (cane length) assessments will take place at least twice during the growing season at each location.

New trials. In the spring and summer of 2015, we will again contact growers to find those replanting acreage and interested in trying new practices. Walters will collect field histories from these growers, will obtain soil type analyses, and will research all options of interest to the grower. Zasada will provide nematode analysis for the fields of interest.

Each participating grower will receive a written evaluation of the field, with projected disease, weed and nematode problems based upon the information collected. They will also receive research on the strengths, weaknesses and costs of the practices they are considering. Once growers decide which, if any, of the alternatives to try, we will work with them to design the trial to facilitate a comparison with standard practices.

Walters will work with participating growers to implement these practices and collect samples prior to fumigation, and following treatment. Disease pressure and weed populations will be assessed before the crop is pulled out, Nematode populations will be assessed prior to fumigation. Expenses associated with fumigation practices will be recorded.

Field day. Walters will organize a field day early in September 2015. At this event, he will present alternatives to be trialed by growers this season. Researchers (Zasada, Lisa Wasco-DeVetter), Trident, and product representatives will also be invited to share their work and their thoughts, as has been done at this field day for the past several years.

Anticipated Benefits and Information Transfer:
Producers will benefit from this work by learning from their peers' experiments with fumigation and alternative practices. They will learn what kind of fields practices have been tried in, how much they cost, and how they succeeded and failed.

This work will be transferred to users at the small fruit meeting in Lynden, and at the fumigation field day.

References:
Garcia-Sinovas D., Garcia-Mendez E., Andrade M.A., Becerril, M., DeCal A., Melgarejo P., Salto T., Martinez-Beringola M.L., Redondo C., Martinez-Treceno A., Medina J.J., Soria C., Lopez-Aranda J.M. 2008. Strawberry nurseries in Spain: Alternatives to MB, 2007 results. 2008 conference on Methyl Bromide Alternatives, accessed at mbao.org.

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

	2014 (expended)	2015	2016 (estimated)
Salaries[1/]	$ 5,000	$4,800	$5,000
Time-Slip	$	$	$
Operations (goods & services) [2/]	$ 1,800	$ 2,550	$ 2,500
Travel[3/]	$ 1,195	$1,193	$1,195
Meetings[4/]	$ 100	$100	$110
Other	$	$	$
Equipment	$	$	$
Benefits	$	$	$
Total	**$ 8,095**	**$ 8,643**	**$ 8,805**

Budget Justification

[1/]Walters, 0.05 FTE, salary and benefits. Grower visits and sampling (6 days), research/data tabulation (4 days), field day, 2 days for field day preparation and hosting.

[2/] $150 for field supplies. Nematode samples to Zasada: 40 soil and 40 root samples in 2015 @$30 each.

[3/] Walters 15 trips Anacortes to Lynden, each 120 miles @$0.56/mile. Zasada, one trip Corvallis-Lynden for field day, $175.

[4/]Supplies (awning, table) and refreshments for field day

Washington Red Raspberry Commission
Final Report

Project No: xxx

Title: Fine-tuning Vydate applications in red raspberry for *Pratylenchus penetrans* control

Personnel: Inga Zasada, USDA-ARS HCRU and Thomas Walters, Walters Ag Research

Reporting Period: 2012-2014 (Final Report)

Accomplishments:
Vydate is an important tool for red raspberry growers to keep *Pratylenchus penetrans*, root lesion nematode, in check during the first and/or second year(s) after planting. The length of *P. penetrans* suppression appears to be related to initial nematode pressure with Vydate being more effective at keeping nematodes at bay when fewer nematodes were present. We did not consistently observe any differences in nematode suppression based upon application timing. However, Vydate is not a strong contact nematicide and is more effective if applications coincide with root growth and the presences of *P. penetrans* in roots. Therefore, we recommend delaying the application of Vydate until May or June to achieve maximum *P. penetrans* suppression.

Results:
2012 Vydate Trials. Three trials were established in newly planted raspberry fields in 2012. Field 1 was planted to Wakefield, field 2 to Chemainus and field 3 to Meeker. At each location, 12 plots were established. To each of four plots, Vydate was applied at a rate of 2 pints/acre twice in May and twice in June. The remaining four plots at each location served as a nontreated control. *Pratylenchus penetrans* population data in soil and roots was determined in spring and fall of 2012 and 2013 as well as spring of 2014 in fields 1 and 3 and fall of 2014 in field 3. In addition, plant vigor was assessed in July of 2012 and 2013 to determine if Vydate is phytotoxic to young raspberry plants. In Fall 2012, regardless of application timing, Vydate reduced *P. penetrans* population densities in roots in all fields (**Table 1**). The length of protection appeared to be driven by the *P. penetrans* pressure present in a field. In field 1, which had the greatest nematode pressure, suppression was only observed 4-5 months after Vydate application. In field 2, which had moderate nematode pressure, protection of plants from *P. penetrans* was observed up to 10-11 months post application. In the field that had the lowest initial nematode pressure, field 3, suppression of *P. penetrans* in roots and soil lasted 2 years post application with the June application having the lowest number of nematodes in roots. Vydate was never found to be phytotoxic to the tested raspberry varieties.

2013 Vydate Trials. Three trials were established in 2013 in newly planted fields of Meeker (field 4) and Wakefield (fields 5 and 6). These trials included the same treatments as the 2012 trials: two May applications, two June applications, and a nontreated control. An additional treatment of two April applications was included. At all dates, Vydate was applied similar to that described above. The first April application was timed to occur when soil temperatures were above 45 °F, followed by a second application three weeks later (the recommendation on the label). Nematode population dynamics in soil and roots were monitored for 2 years; plant vigor was assessed in July of both years. The soil and root *P. penetrans* population data is presented in **Table 2**. Field 4 was considered a low pressure field and in this field *P. penetrans* in roots were suppressed up to 1 year post application. In field 5, a moderate pressure field, there were few consistent differences among the treatments. In field 6, a high pressure field which had substantial *P. penetrans* population densities after soil fumigation, *P. penetrans* populations in roots 6 months after a June Vydate application were lower than populations in the nontreated control. In general, there was no difference in application timing on *P. penetrans* control. Similar to the 2012 trials, no phyotoxicity to raspberry was observed.

Outputs:

Findings from this research were presented at the Small Fruit Conference in 2012 and at a field day in 2014. We have just finished processing (October 2014) the last samples from this project and expect to submit these research findings to HortScience as a peer-reviewed manuscript in the near future. In addition, in collaboration with Dr. Lisa Wasko-Devetter we will prepare a WSU Extension Publication on a BMP for non-bearing Vydate applications to raspberry.

Table 1. Population dynamics of *Pratylenchus penetrans* in roots and soil in red raspberry cultivars over time after the post-plant application of Vydate (oxamyl) in spring 2012.

	Spring 2012	Fall 2012	Spring 2013	Fall 2013	Spring 2014	Fall 2014
	Pratylenchus penetrans/100 g soil					
Field 1 (Wakefield)						
Control	0	55	44 a*[a]	450	175	nd
May 2x	0	32	10 b	238	133	nd
June 2x	0	18	24 ab	218	203	nd
Field 2 (Chemanius)						
Control	0	29 a***	53 a***	213 a***	nd	nd
May 2x	0	1 b	2 b	54 b	nd	nd
June 2x	0	1 b	5 b	85 b	nd	nd
Field 3 (Meeker)						
Control	0	218 a**	25 a***	63	50 a***	450 a*
May 2x	0	2 b	1 b	11	1 b	110 b
June 2x	0	0 b	3 b	6	3 b	74 b
	Pratylenchus penetrans/g dry root					
Field 1 (Wakefield)						
Control	nd	612 a**	260	2,758	546	nd
May 2x	nd	175 ab	320	1,412	259	nd
June 2x	nd	147 b	241	1,863	1,145	nd
Field 2 (Chemanius)						
Control	nd	103 a***	448 a***	760	nd	nd
May 2x	nd	3 b	11 b	722	nd	nd
June 2x	nd	3 b	18 b	1,003	nd	nd
Field 3 (Meeker)						
Control	nd	38 a**	17	841 a***	498 a***	539 ab*
May 2x	nd	2 b	2	5 b	33 b	1,741 a
June 2x	nd	2 b	1	10 b	22 b	311 b

aValues followed by the same letter within a sampling time are not significantly different a significance levels of *p $\geq$ 0.1, ** $\geq$ 0.01, and *** $\geq$ 0.001.

Table 2. Population dynamics of *Pratylenchus penetrans* in roots and soil in red raspberry cultivars over time after the post-plant application of Vydate (oxamyl) in spring 2013.

	Spring 2013	Fall 2013	Spring 2014	Fall 2014
	Pratylenchus penetrans/100 g soil			
Field 4 (Meeker)				
Control	0	0	4	6
April 2x	0	0	1	7
May 2x	0	1	2	6
June 2x	0	1	0	5
Field 5 (Wakefield)				
Control	0	3	2	21
April 2x	0	6	4	75
May 2x	0	0	0	5
June 2x	0	1	1	54
Field 6 (Wakefield)				
Control	52	63	83	92
April 2x	43	35	99	154
May 2x	19	30	32	75
June 2x	31	22	14	95
	Pratylenchus penetrans/g dry root			
Field 4 (Meeker)				
Control	nd	16 a*[a]	16 a*	83
April 2x	nd	2 b	4 ab	16
May 2x	nd	3 b	2 b	35
June 2x	nd	2 b	6 ab	41
Field 5 (Wakefield)				
Control	nd	152	20 ab*	105
April 2x	nd	184	46 ab	444
May 2x	nd	52	7 b	49
June 2x	nd	72	34 a	260
Field 6 (Wakefield)				
Control	Nd	916 a*	692	529
April 2x	nd	547 a	552	454
May 2x	nd	891 a	341	331
June 2x	nd	51 b	212	251

[a]Values followed by the same letter within a sampling time are not significantly different a significance levels of *p $\geq$ 0.1, ** $\geq$ 0.01, and *** $\geq$ 0.001.

2015 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

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

Project Title: Efficacy of Drip-applied Vydate for newly planted raspberry

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Cooperators: Norm McKinley, DuPont

Year Initiated 2015 Current Year 2015 Terminating Year 2016

Total Project Request: Year 1 $ 1,630 Year 2 $ 1,000

Other funding sources: DuPont Chemical, requesting $5,750. WSCPR, Requesting $5,750
Notes: Total matching is $11,500, approximately 7X amount requested from WRRC

Description:
Raspberry growers can use Vydate on non-bearing acreage, under the SLN 24(c) label issued by EPA and supported by WSDA. This is the only postplant treatment known to be effective against the root lesion nematode *Pratylenchus penetrans*. The current label allows application after planting and before rainfall or overhead irrigation to incorporate the product into the soil. However, most raspberry growers do not overhead irrigate, and the unpredictability of rainfall means that Vydate could be inadequately incorporated, or washed away from the target area after application. DuPont has indicated their interest in adding a drip application to this label. If added, a drip application could be more reliable than a surface application, because applications can be made at the most effective time (rather than only before a rain event), and the amount of water used for incorporation can be controlled. This application method should also minimize the risk of Vydate movement outside the root zone.

Justification and Background:
Raspberry growers lack postplant measures for *P. penetrans* control. The only known effective, labeled treatment is Vydate, which can be applied to nonbearing raspberry under a 24(c) label. This label allows up to two soil surface applications in a nonbearing year (generally the planting year) prior to rainfall or overhead irrigation. Oxamyl, the active ingredient in Vydate, photodegrades quickly, and must be moved below the soil surface soon after application. For best efficacy, oxamyl should not be moved below the root zone. Oxamyl is not a highly effective contact nematicide for *P. penetrans*, and appears to function better in the plant root than in the soil (Zasada et al., 2010).

Most growers do not have overhead irrigation available, and therefore rely on rainfall to incorporate Vydate. However, rainfall events are unpredictable. Too little rain may move oxamyl inadequately resulting in photodegradation and limited root uptake. Too much rain can move oxamyl past the root zone, resulting in both lost efficacy and potential groundwater contamination. A drip application would allow growers to target the plant root zone much more accurately than relying upon the whims of rainfall.

Last summer, WSDA released their 2013 water quality sampling data from numerous selected waterways, including Bertrand Creek (WSDA, 2014). Oxamyl and oxamyl oxime were consistently detected at very low levels in the Bertrand. These levels are several orders of magnitude below environmental or human health thresholds, but their constant presence drew the attention of WSDA scientists. WSDA continues to support the existing 24(c) label for Vydate for use on raspberry. However, in the interest of best stewardship of Vydate, DuPont has offered to support research that would lead to adding a drip application to the 24(c) label. Growers could then choose their preferred application method.

We compared drip and soil-applied Vydate treatments previously in an established raspberry field (Walters et al., 2009). Both treatments reduced *P. penetrans* and *Xiphanema* population densities, but surface applications were more effective than drip applications. This may have been a result of the difficulty in getting thorough coverage of the large root zone occupied by established raspberries. In the present project, we only need to protect a much smaller root zone, which should be easier to accomplish with a drip application.

There are no comparable ongoing projects in British Columbia, Idaho or Oregon.

Relationship to WRRC Research Priority(s):
This work relates to the #1 priority of “soil fumigation techniques and alternatives...”, as the Vydate use pattern in question is in the planting year; it is used to supplement the current fumigation practices.

Objectives: (both to be addressed this funding year)

1) Compare *P. penetrans* numbers in roots and soil of plots with drip-applied Vydate to those in plots with surface-applied Vydate in a newly planted red raspberry field.
2) Monitor oxamyl levels below the root zone in these plots.

Procedures:
An appropriate field will be identified (Jan-March), in which raspberries are to be planted following raspberries, and which had a significant *P. penetrans* population density prior to fumigation in 2014. Once the field is planted (March-April), plots will be laid out, and drip tape will be buried in plots to receive buried drip treatment. Each plot will be approximately 30 ft long x 1 row wide. Four replicate plots of each treatment will be established. Treatments will include:

- Nontreated check

- Surface application of Vydate L at 2 qt/A according to the current 24(c) label, watered in with ½ inch of water following each application. The first application will be made in late May, followed by a second in mid-June.
- Application via overhead drip. Application rates and dates will be the same as for surface application treatments.
  Each application will be made in an appropriate amount of water to reach 80% of the root zone (estimated to be approximately ½ inch, will be confirmed with tensiometers).
- Application via buried drip. Application rates and dates will be the same as for surface and overhead drip application treatments.

P. penetrans population densities in the soil will be assessed prior to treatments. Soil and root *P. penetrans* population densities will be assessed in September. Soil and root P. penetrans will also be assessed in April and September of the following year, 2016.

Soil cores (5-8) will be collected from each plot to an 18” depth 2, 7 and 14 days after the first Vydate treatment. Each core will be partitioned into 0-6”, 6-12”, and 12-18” depths. On each date, the 12-18” depth samples will be composited by treatment, and will be submitted to Pacific Analytical Labs for oxamyl assessment. In addition, on the first sampling date (2 DAT), the 0-6” and 6-12” samples from the surface application and buried drip treatments will be submitted.

Anticipated Benefits and Information Transfer:
Based on prior experience, we expect that the surface Vydate application will provide 1-2 years’ protection from *P. penetrans*. If drip applications provide comparable protection, they will be an important addition to the 24(c) label. Addition of the drip application will make Vydate application simpler for raspberry growers, and will eliminate the uncertainty of incorporating with. This should result in improved reliability of Vydate applications, and will also reduce the risk of Vydate movement beyond the root zone. Results will be transferred at field days and the Small Fruit Conference.

References:
Walters TW, Pinkerton JN, Riga E, Zasada IA, Particka M, Yoshida HA. 2009. Managing Plant Parasitic Nematodes in Established Red Raspberry Fields. HortTechnology 19:762-768

Washington State Department of Agriculture. 2014. Surface Water Monitoring Program for Pesticides in Salmonid-Bearing Streams, 2013 Data Summary. Accessed October 30 2014 at http://agr.wa.gov/FP/Pubs/docs/411-SWM2013Report.pdf .

Zasada IA, Walters TW, Pinkerton JN. 2010. Post-Plant Nematicides for the Control of Root Lesion Nematode in Red Raspberry. HortTechnology 20:856-862.

Budget:

	2015-WRRC	2015-WSCPR match	2015-DuPont match	Total Budget
Salaries[1/]	$ 500	$2150	$2150	$4800
Time-Slip	$	$	$	
Operations[2/]	$ 880	$3000	$3000	$6880
Travel[3/]	$ 250	$ 600	$ 600	$1450
Meetings	$	$	$	
Other	$	$	$	
Equipment[3/]	$	$	$	
Benefits[4/]	$	$	$	
Total	**$1,630**	**$5,750**	**$ 5,750**	**$13,130**

Budget Justification

[1/]Walters, 0.05 FTE.

[2/]$3400 lab costs Zasada. $600 for rental equipment. $2880 for oxamyl analysis in soil. Currently budgeted for Pacific Analytical Laboratories, but it may be possible for DuPont to provide analyses in-house.

[3/]Zasada $1,000 (2 trips) and Walters $450 (4 trips) to cover travel to field site for sampling and treatment application.

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

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

WASHINGTON RED RASPBERRY COMMISSION
Progress Report for 2014 Projects

Project No: xxx

Title: Characterizing the soil ecology of red raspberry produced under different production regimes

PI: Inga Zasada and Christopher Dunlap, USDA-ARS and Chris Benedict, WSU

Reporting Period: 2014

Accomplishments: We have begun to characterize soil and root microbial communities associated with raspberry providing an important baseline dataset to help the industry understand soil ecology and soil borne pathogens and their effects on plant health and crop yields. One of the long-term raspberry sites maintained by Chris Benedict is being used for these analyses providing additional valuable information on the impact of different cropping practices on raspberry productivity. This baseline data will form the cornerstone for future research questions regarding biological control of pathogens and insects and organisms contributing to replant disorder of raspberry.

Results: Samples were collected from two treatments in the LTRSE trial: standard fertilizer and compost. From each treatment five samples were collected from replicated plots with soil and root material being sent to Chris Dunlap for microbial analysis. To date, samples were collected in the spring and fall of 2014 with only data from the spring 2014 being available at this time. In the laboratory, DNA was extracted from soil surrounding raspberry roots and from raspberry roots after sonication to remove adhering contaminants. From both of these samples, fungal and bacterial communities were determined. Some of the highlights from our initial analyses include:

- There was no difference in the bacterial communities of composted vs standard fertilizer treatments in the spring samples. Even though there was no difference, there could be a large difference in function of members of these bacterial communities.
- The fungal communities were more diverse and analysis hasn't been completed yet. The most common plant pathogen found in bulk soil was *Botryotinia fuckeliana* the causal agent of gray mold disease (*Botrytis cinerea*). This is an interesting finding because it introduces the question of what contribution does soil inoculum of *Botrytis* play in fruit disease?
- The fungal endoyphytes of roots were the most consistent and most interesting. The most prevalent fungi identified in raspberry roots (99% of all fungi) were: *Debaramyces prosopids* (salt tolerant yeast), *Trichoderma harzianum* (biocontrol agent of plant pathogens), *Davidiella tassiana* (fruit rot pathogen), and *Debaryomyces marasmus* (unknown function).
- Another interesting finding was that all known beneficial fungi were root endophytes. For example, when *Beauveria bassiana*, an insect pathogen, was present so were other insect pathogens such as *Isarai farinose* and *Lecanicillium lecanii*. This result suggests there may be a specific plant response and microbial community response to insect feeding.

2015 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

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

Project Title: Characterizing the soil ecology of red raspberry produced under different production regimes

PI: Inga Zasada
Organization: USDA-ARS Horticultural Crops Research Unit
Title: Research Plant Pathologist
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Co-PI: Christopher Dunlap
Organization: USDA-ARS Crop Bioprotection Research Unit
Title: Research Scientist
Phone: (309)681-6339
Email:christopher.dunlap@ars.usda.gov
Address: 1815 N. University St.
City/State/Zip: Peoria, IL 61604

Cooperator: Chris Benedict, WSU, Bellingham WA

Year Initiated___2014___ **Current Year**____2015____ **Terminating Year**___2015___

Other sources of funding: Dr. Zasada's base CRIS funds cover the salary of the PI as well as her technician (~$42,500/year for 25% of their time). Dr Dunlap's base CRIS funds cover the cost of the technician that performs the NGS library preparation and running the sequencing equipment. In addition, Dr Dunlap's lab will provide the DNA barcodes required for multiplexing samples, which saves $100 a sample ($16,000) relative to life technologies retail kit. No support is requested to offset $120,000 in annual equipment maintenance agreements of the sequencing facility.

Description:
Understanding soil ecology and effects on plant health and productivity has long been a #1 research priority of the Washington Red Raspberry Commission. A unique opportunity has presented itself to enable the first look at raspberry soil ecology. Dr. Dunlap is the technical coordinator of the next-generation sequencing (NGS) facility at National Center for Agricultural Utilization Research in Peoria, IL. Dr Dunlap's leadership in this area has lead to a capital investment of over $1 million in the facility and has greatly increased the technical capabilities of the center. Dr Dunlap has lead NGS projects on beneficial bacterial genomics and has international collaborations on microbial ecology (Brazil) and fungal transcriptomics (Australia). We also now have two long-term raspberry experiments in Whatcom County established by Mr.

Chris Benedict. These experiments provide an ideal venue in which to explore the impact of different raspberry production regimes (compost and nutrient management) on soil ecology and raspberry productivity. This team of scientists will work together and begin to understand raspberry soil ecology and effects on plant health and productivity.

Justification and Background:

Soil health is driven by the individual and combined contributions of the physical, chemical and biological processes occurring in soil. From an agricultural perspective the services that are provided by the soil to sustain plant productivity include such things as nutrient availability, pest suppression, and increased water holding capacity. In perennial production systems there has been increasing interest in understanding soil health, and specifically soil microbiology and the role it may replant disorders (Mazzola, 1998; Yang et al., 2012). Based upon conversations with Washington raspberry growers there is a feeling that the raspberry production system may be experiencing similar replant issues as have been observed in other perennial production systems. Beginning to explore the ecology of microorganisms in the soil may provide insights into raspberry production systems that support unique microbial communities that encourage long-term productivity and economic viability. It may also be possible to identify microbial agents of disease that are not currently known or understood in raspberry.

Mazzola and Manici (2012) highlighted the dynamic ways by which a soil microbial community can function within a perennial cropping system. A microbial community can cause disease. Molecular methods have been used to identify differences in microbial communities between replant and nonreplant impacted orchards (Rumberg et al., 2007; Yang et al., 2012). Three different fungi, one oomycete, and a plant-parasitic nematode were found to contribute to apple replant disorder (Mazzola and Manici, 2012). Clearly different strategies will be required to manage such a diverse array of organisms. Molecular methods have also been used to identify microorganisms that provide valuable ecosystem services, such as disease suppression. Disease suppressive soils are exceptional ecosystems in which crop plants suffer less from specific soil-borne pathogens than expected owing to the activities of other soil microorganisms. Mendes et al. (2011), (Dr Dunlap's Brazilian collaborator) recently reported upon fungal root pathogen attack where plants can exploit the soil microbial consortia to prevent infection.

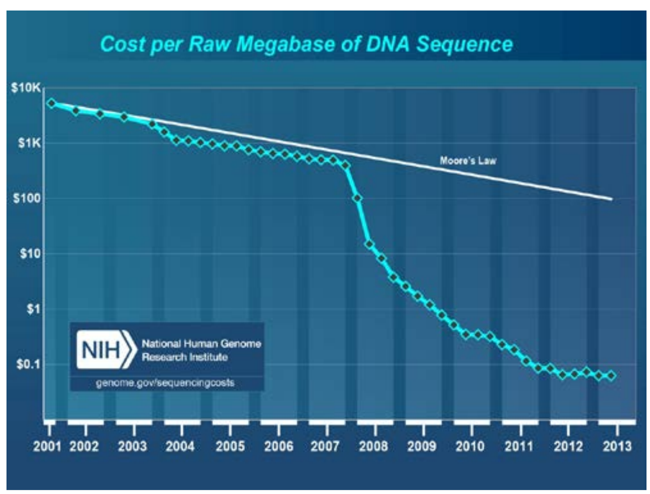


Figure 1. Cost per raw megabase of DNA sequence.

The rapid decrease in the cost of high-throughput DNA sequencing has opened new opportunities to study microbial ecology. **Figure 1** shows the cost of sequencing is 10,000x cheaper than six years ago. This technological revolution has permitted population metagenomics to become a more routine experiment. Population metagenomics is an emerging molecular biology field to study environmental microbial populations by sequencing DNA extracted from the environment to quantify the species present. We will use this technology to explore soil and root microbial ecology in raspberry production systems.

Relationship to WRRC Research priority(s):
This proposed research directly addresses a priority of the WRRC, understanding soil ecology and soil borne pathogens and their effects on plant health and crop yields.

Objectives:
1. Characterize microbial ecology (fungal, bacterial and nematode) under different raspberry production regimes, and;
2. Evaluate plant productivity (yield and disease) and relate that to microbial ecology.

Procedures:
We propose to evaluate microbial communities in two long-term on-farm trials established in Whatcom County by Mr. Chris Benedict. These trials have been established to compare different raspberry production regimes including irrigation, fertilizer, compost applications, and cover crops. For the purpose of this research we will compare the microbial communities in the roots and soil surrounding roots of raspberries produced conventionally (i.e. with standard fertilizer program) to those produced with a modified fertilizer program (either organic or based upon soil test data). Within the established experimental design samples will be collected from five replications of each treatment.

Soil and root samples will be collected in the spring and fall of 2015. At each collection date, samples will be collected from plants in the center of plots. Cores, 4 x 4 x 4 inches, will be collected from two plants directly in the root zone (about 6 inches from the base of the plant). The samples containing roots and soil will be combined, placed in a plastic bag and transported to the laboratory. Once in the lab the samples will be partitioned to allow for microbial analyses of root and soil. A subsample of soil and fine roots will be shipped overnight to Dr. Dunlap. A flow chart of sample handling is provided is **Appendix A**. After DNA extraction, PCR will be performed to generate 400 bp amplicons using standard primers for the 16S gene (bacterial) or ITS gene (fungal) for the samples. The resultant amplicons will be barcoded and prepared for NGS sequencing. The samples will be sequenced in our facility using Ion Torrent sequencing technology. The sequencing reads will be analyzed using MG-RAST metagenomics analysis server. The ratio of microbial species present will be determined and statistically analyzed.

Plant productivity will be evaluated by measuring the number and height of primocanes in July of 2015. Dormant primocane assessment (diameter) will occur in later winter.

Timeline:

Activity	**2014 (Completed)**	**2015**
Sample soil and roots	April, Sept	April, Sept
Plant vigor assessment	July	Feb and July
Data processing and analysis	All year	All year

Anticipated Benefits and Information Transfer:

This research will provide the first information on soil ecology in red raspberry production systems. Our research will establish a baseline upon which to build. Plant genotype is believed to be the driving force in rhizosphere ecology; this baseline provides a method to compare raspberry cultivars. Another long term goal would be to understand the potential of disease suppressive soils in red raspberry production systems. Our research results will be presented to red raspberry growers at meetings (Berry Workshop, Lynden). Results will also be communicated to the Washington Red Raspberry Commission and to Peerbolt Crop Management for inclusion in their newsletters.

References:

Mazzola, M., Manici, L.M. Apple replant disease: role of microbial ecology in cause and control (2012). Annual Review of Phytopathology 50, pp. 45-65

Mendes, R., Kruijt, M., De Bruijn, I., Dekkers, E., Van Der Voort, M., Schneider, J.H.M., Piceno, Y.M., DeSantis, T.Z., Andersen, G.L., Bakker, P.A.H.M., Raaijmakers, J.M. Deciphering the rhizosphere microbiome for disease-suppressive bacteria (2011) *Science*, 332 (6033), pp. 1097-1100.

Rumberg, A. Merwin, I.A., Thies, J.E. Microbial community development in the rhizosphere of apple trees at a replant disease site (2007). Soil Biology and Biochemistry 39, pp. 1645-1654

Yang, J., Ruegger, P.M., McKenry, M.V., Becker, J.O., Borneman, J. Correlations between root-associated microorganisms and peach replant disease symptoms in a California soil (2012). Plos One, 7 (10), pp. 1-10.

Budget:

	2014	2015
Salaries	$	$
Administrative Professional	$	$
Time-Slip[1/]	$5,000	$5,000
Operations (goods & services)[2/]	$12,400	$8,300
Travel[3/]	$525	$700
Other	$0	$0
Equipment	$0	$0
Benefits	$0	$0
Total	**$17,925 (received $14,000)**	**$14,000**

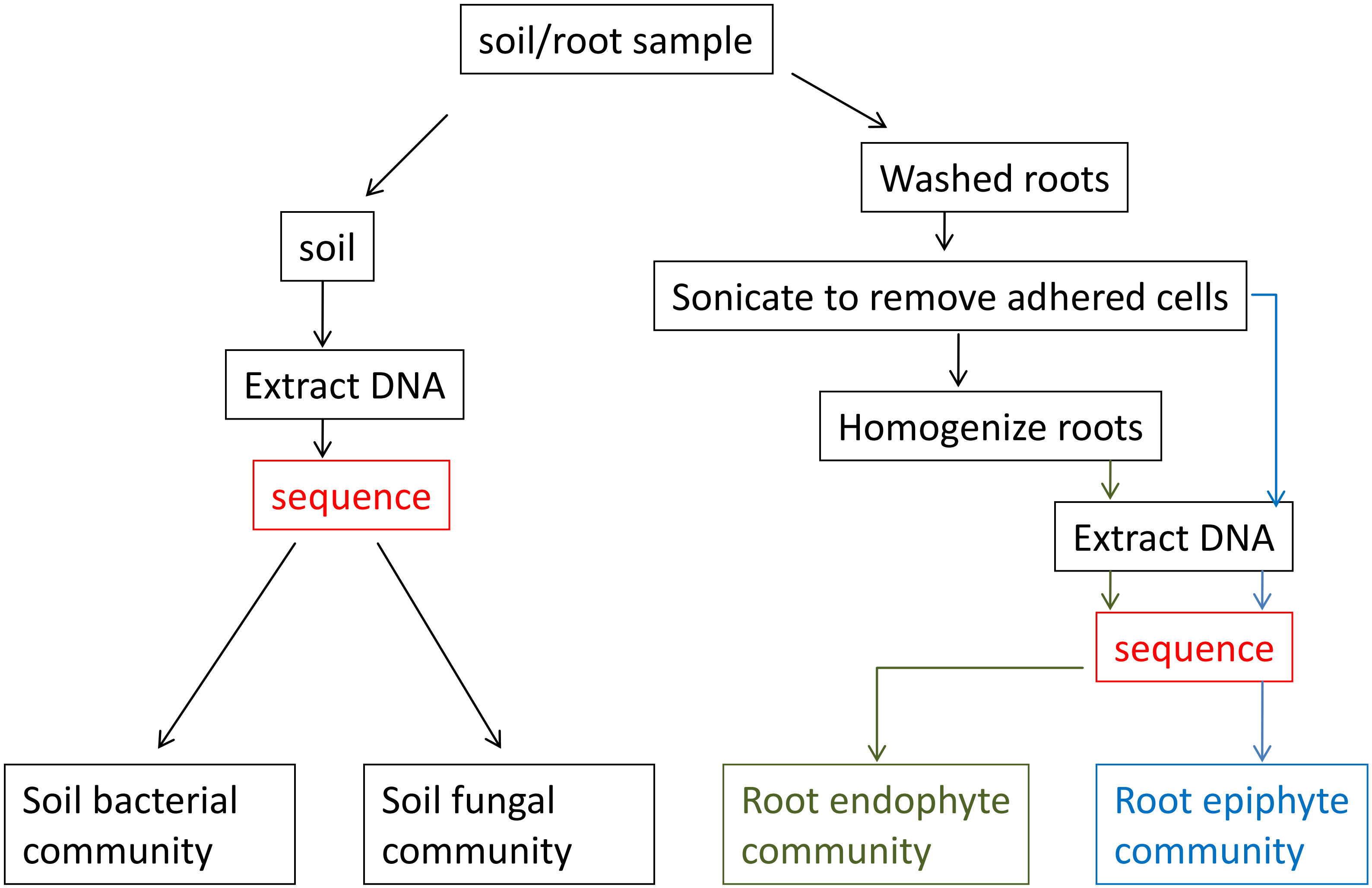
Budget Details

[1/]One part time student will be hired in each year to support Dr. Dunlap's research efforts.

[2/] Microbial community analysis for 20 samples, processed for six communities = 120 sequencing samples at ~$70 sample ($8,300/yr).

[3/] For Dr Dunlap to participate in WRRC annual meeting.

APPENDIX A: Metagenomics sample handling



CURRENT & PENDING SUPPORT

Name: Christopher Dunlap

Instructions:
Who completes this template: Each project director/principal investigator (PD/PI) and other senior personnel that the Request for Applications (RFA) specifies
How this template is completed:

- Record information for active and pending projects, including this proposal.
- All current efforts to which PD/PI(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.
- Provide analogous information for all proposed work which is being considered by, or which will be submitted in the near future to, other possible sponsors, including other USDA programs.
- For concurrent projects, the percent of time committed must not exceed 100%..

Note: Concurrent submission of a proposal to other organizations will not prejudice its review by CSREES.

NAME (List/PD #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
Zasada and Dunlap	**Active:** Washington Red Raspberry Commission	$14,000	3/31/2014-3/31/2015	2%	Characterizing the soil ecology of red raspberry produced under different production regimes
	Pending:				

CURRENT & PENDING SUPPORT

Name: Inga Zasada

Instructions:
Who completes this template: Each project director/principal investigator (PD/PI) and other senior personnel that the Request for Applications (RFA) specifies
How this template is completed:

- Record information for active and pending projects, including this proposal.
- All current efforts to which PD/PI(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.
- Provide analogous information for all proposed work which is being considered by, or which will be submitted in the near future to, other possible sponsors, including other USDA programs.
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NAME (List/PD #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Active:				
Walters, Moore, Zasada, Grunwald, Peerbolt, Bolda	USDA-NIFA-RAMP	831,869	9/2010 - 8/2015	5%	A new way of managing soil borne diseases of raspberry in western states: development of decision making tools and sustainable management systems
Moyer & Zasada	Washington State Grape & Wine Research	42,565	6/2014 - 5/2015	10%	Impact and management of plant-parasitic nematode in Washington vineyards
Zasada & Walters	Washington Red Raspberry Commission	5,883	5/2014 – 4/2015	2%	Fine-tunning vydate applications in red raspberry for *Pratylenchus penetrans* control
Walters & Zasada	Washington Red Raspberry Commission	8,095	5/2014 – 4/2015	2%	Evaluating soil fumigation alternatives in Washington raspberry fields
Zasada, Dunlap, Benedict	Washington Red Raspberry Commission	14,000	5/2014 – 4/2015	2%	Characterizing the soil ecology of red raspberry produced under different production regimes
Dandurand et al.	NW Potato Research Consortium	118,238	7/2014 – 6/2015	5%	Eradication strategies for *Globodera* pallida: use of trap crops
Dandurand et al.	NW Potato Research Consortium	78,930	7/2014 – 6/2015	1%	Functional genomics of *Solanum sisymbriifolium* (lichi tomato) immunity for PCN eradication
Dandurand, Navarre, Zasada	NW Potato Research Consortium	39,100	7/2014 – 6/2015	5%	Eradication strategies for *Globodera* spp.: hatching factors
Dandurand et al.	USDA-APHIS	307,237	7/2014-6/2015	5%	*Globodera* eradication
Dandurand et al	USDA-APHIS	470,306	7/2014-6/2015	1%	*Globodera* immunity
Navarre et al.	USDA-ARS	76,712	6/2013-5/2014	5%	Identification of hatching factors for *Globodera* hatch
	Pending:				
Knudsen, Dandurand, Zasada	USDA-NIFA	518,946	2015-2017	10%	Multitrophic community determinants of potato cyst nematode (*Globodera* spp.) biocontrol

Zasada, Weiland, Wasko DeVetter, Walters, Benedict	NWCSFR	29,087	2014	5%	Raspberry root removal: eliminating pre-plant pathogen inoculum to improve management
Dandurand et al	USDA-AFRI	7,000,000	2015-2019	15%	Risk assessment and eradication of *Globodera* species in US potato production of potato
Wasko DeVetter, Zasada, Mazolla,, Walters	USDA-NIFA	150,000	2015-2018	5%	Developing effective methods for soilborne pathogen management through removal of root inoculum in continuous red raspberry production systems