WASHINGTON Red Raspberries

2013 Research Proposals

and

2012 Research Reports

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

Year	Seat	
10	1	Vacant - District #2
13	2	Adam Enfield, President Lynden 360-354-3019 adam@enfieldfarms.com
1	3	Kristie Clark, Treasurer Lynden (360) 354-1294 clarksberryfarm@hotmail.com
14	4	Ralph Minaker Everson 360-966-5645 minakerfarm@aol.com
12	5	George Hoffman Ridgefield (360) 921-2522 CAROLDHOFFMAN@aol.com
12	6	Richard Sakuma Burlington 360-757-1855 richards@sakumabros.com
09	7	Vacant - District #2

Year	Seat	
13	8	Kyle Haugen Lynden 360-815-1346 il.com
12	9	Erin Thoeny Woodland 360-225-7133 thoenyf@cni.net
14	10	Vacant - District #4
WSDA	11	Bill Dallas Olympia 360-902-1925 bdallas@agr.wa.gov

WRRC Office

Henry Bierlink, Executive Director
henry@red-raspberry.org
Tom Krugman, Marketing Director
tomk@red-raspberry.org
Hannah Coyne, Office Manager
1796 Front Street
Lynden, WA 98264
(360) 354-8767

2013 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
- Understanding soil ecology and soil borne pathogens and their effects on plant health and crop yields.
- Fruit rot including pre harvest, post harvest, and/or shelf life.
- Soil fumigation techniques and alternatives to control soil pathogens, nematodes, and weeds.
- Evaluation of the life cycle and management options of the Spotted Wing Drosophila

#2 priorities

- Harvest contaminants and problems stemming from the loss of longstanding insecticides.
- Weed management
- Nutrient/Irrigation management
- Viruses/crumbly fruit
- Mite management

#3 priorities

- Vertebrate pest management
- Product and Production Certification Systems - food safety & security, standards, traceability
- Season extension: improve viability of fresh marketing
- Labor saving cultural practices including mechanical pruning and tying techniques.
- Foliar & Cane Diseases – i.e. spur blight, yellow rust, cane blight, etc.

Table of Contents

Primary Investigator	Product	Page
Benedict	Report	4
	Proposal	5
Burrows	Report	11
	Proposal	12
Daniels	Report	15
Dossett/Kempler	Report	20
Dossett	Report	29
	Proposal	32
Elling	Report	37
	Proposal	38
Finn	Report	43
	Proposal	51
Finn - SCRI	Report	56
	Proposal	58
Karkee	Report	61
Miller	Report	67
	Proposal	69
Moore - Verticillium	Proposal	72
Moore	Report	77
	Proposal	82
Peerbolt	Report	86
	Proposal	88
Schreiber	Proposal	92
Tanigoshi	Report	95
	Proposal	100
Weiland/Benedict	Proposal	104
Zasada/Walters	Proposal	110

2013 WRRC Production Research Budget Worksheet

PROJECT TITLE	RESEARCHER (S)	REQUEST of WRRC	Other Sources	WSCPR Applied	Total Project	WRRC Approved	WRRC %
Developing the Genomic Infrastructure for Breeding Improved Black Raspberries	Finn	$1,000	$52,506		$53,506		2%
Cooperative raspberry cultivar development	Finn	$6,500	$3,000		$9,500		68%
Red Raspberry Breeding	Moore	$68,000	$138,424		$206,424		33%
Red Raspberry Cultivar Development	Dossett	$12,000	$64,174		$76,174		16%
Evaluating the Feasibility of Coordinated Regional on-farm Trials of Advanced Raspberry Selections	Peerbolt	$11,200			$11,200		100%
Connecting Raspberry Breeding Programs to Crop Markets through Use of Molecular, Economic and Consumer Science Tools	Daniels	$1,000	$2,800,000		$2,801,000		0%
Evaluation of resistance to *Verticillium dahliae* and *Phytophthora rubi* in red raspberry	Moore Weiland	$6,772	$10,000		$16,772		40%
Incidence and Detection of *Verticillium dahliae* in Red Raspberry Production Fields	Weiland Benedict	$13,582			$13,582		100%
Chemical control of spotted wing drosophila and spider mite	Tanigoshi	$9,921		$7,904	$17,825		56%
Trap and bait testing for SWD in Northwest Washington Raspberries	Burrows	$4,934	$4,934		$9,868		50%
Perennial Weed Control	Miller	$4,595		$4,250	$8,845		52%
Strategies to Control Nematodes	Elling	$7,457	$317,424		$324,881		2%
Fine-tuning Vydate applications in red raspberry for *Pratylenchus penetrans* control	Zasada Walters	$10,447	$5,840		$16,287		64%
Red Raspberry trellising demonstration plot for development of automation technologies	Karkee Tarara	$11,451			$11,451		100%
Integration of Factors to Improve Soil Health in Red Raspberry Production	Benedict	$10,736	$125,306		$136,042		8%
Fungicide Resistance in Botrytis in WA Berries	Schreiber	$3,000	$3,300	$5,000	$11,300		27%
Future Projects					$0		
Total Production Research		**$182,595**	**$3,524,908**	**$17,154**	**$3,724,657**	**$0**	
Research Related	WRRC expenses	$5,000			$5,000	$5,000	
Small Fruit Center fee		$2,500			$2,500	$2,500	
TOTAL		**$190,095**	**$3,524,908**	**$17,154**	**$3,732,157**	**$7,500**	
2013 Proposed Research Budget		$135,000					

2012 WASHINGTON RED RASPBERRY COMMISSION PROGRESS REPORT

Project No: 13C-4127-1260

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

Personnel:

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

Co-PI and/or cooperator(s)
Colleen Burrows, WSU Whatcom County Extension,
Agriculture Special Projects Coordinator
1000 N. Forest St. Suite 201,
Bellingham, WA, 98225.
(360) 676-6736
cburrows@wsu.edu

Reporting Period: 1/1/12-12/31/12

Accomplishments:

The first year of this project was to initiate treatments, setup monitoring equipment, and capture baseline soil-health and horticultural data. Plant health was captured through primocane diameter measurements (Spring 2012) and visual assessments throughout the year (Spring, Summer, Early-Fall 2012). Soil health was evaluated through physical (texturization), biological (nematode/soil-pathogen quantification and soil biota community assemblage characterization), and chemical (soil nutrient levels) analysis. These measurements give us a starting point for reference for future years when a similar suite of analysis will be performed. This information contributes to the industry's knowledge-base and the larger scientific community by quantifying soil-pathogen levels and within-field geospatial distribution.

Results:

To date soil texturization, soilborne pathogens (i.e. *V. dahliae*), soil biota community assemblage, soil nutrient analysis, horticultural measurements, and SPAD meter readings have been compiled. Lab analysis of soilborne pathogens (i.e. nematode, *P. rubi*,) and foliar nutrient content (to be correlated to SPAD readings) have not been finalized. A set of tensiometer-driven irrigation lines were installed that shut-offs at desired soil moisture levels. After getting through some installation "speed bumps" the tensiometer driven irrigation system reduced water use by 30% at one site and 23% at the other when compared to timed-based irrigation. Cover crop screens have identified two spring planted cover crops that can easily be used in raspberry production, withstand harvest operations, and provide little crop competition.

Publications:

We are in the process of developing an in-depth written report for the December issue of Whatcom Ag Monthly. Additionally interactive web space is being developed that will be posted before the Small Fruit Conference that will allow information to be available in real-time to interested producers, industry support personnel, and researchers. Result from the SPAD metering will be developed into a poster for the Small Fruit Conference and for a peer-reviewed scientific journal once lab work is completed.

2013 WASHINGTON RED RASPBERRY COMMISSION
RESEARCH PROPOSAL

New Project Proposal **Proposed Duration:** 1-year
Project Title: Integration of Factors to Improve Soil Health in Red Raspberry Production

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

Co-PI and/or cooperator(s)
Colleen Burrows, WSU Whatcom County Extension,
Agriculture Special Projects Coordinator
1000 N. Forest St. Suite 201,
Bellingham, WA, 98225.
(360) 676-6736
cburrows@wsu.edu

Year Initiated 2012 **Current Year** 2013 **Terminating Year: 2013**
Total Project Request: $10,736 **Year 1 $10,736** **Year 2 $** **Year 3 $**
Other funding sources: BIOAg Grant Program- $9,167 awarded
Agency Name: WSU Center for Sustaining Agriculture and Natural Resources
Notes: These grant funds are to be used to bring together regional experts to discuss solutions around soil health declines in red raspberries and to develop a grant proposal for a multi-year project (WSDA-SCBG & WSARE). We intend to highlight this project at this meeting and to use it as a centerpiece to bring collaboration from various disciplines.

Description: Many red raspberry producers have witnessed a reduction in the harvestable productivity of a planting; this is suspected to be due to declines in soil health. 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 soil health declines. To overcome these declines, producers are relying on increased inputs which have resulted in increased production costs. Past research has evaluated the causes of soil health decline and potential solutions to the issue in a reductionistic way; it has only evaluated a portion of the overall production system. This project will continue efforts that began in 2012 that includes evaluation of ground covers (spring and postharvest planted), alternative nutrient sources/rates (organically derived sources/spring soil test-driven), and efficient water delivery mechanisms (tensiometer driven) and 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 evolution of the system over time as basic knowledge is obtained.

Justification and Background: Raspberry growers have noticed a decrease in duration of productive plantings, costing significant amounts in income losses and replant costs. One suspected reason is the decline in soil health, a loss of soil organic matter and beneficial soil biological activity, and subsequent increase in soil-borne diseases such as root rot (*Phytophthora rubi)* and nematodes (*Pratylenchus penetrans).* A reliance on fumigation and post plant soil-applied pesticides has been used to attempt to overcome these issues, but is being compromised by changes in use-regulations.

While development of resistant varieties to these pests is the long-term goal, other methods have been tested to manage root rot and nematodes. Solarization has shown potential, but the effect was short lived (Pinkerton et al., 2009). Other cultural options, such as fallow periods, are not economically optional for many producers and management of this fallow period can lead to declines in other soil health parameters (Forge et al., 2000). The use of small grain ground covers to reduce *P. penetrans* populations has had mixed results; in some studies reductions have occurred (Forge et al., 2000), while in others populations were not significantly reduced (MacGuidwin and Layne, 1995). This project will evaluate the use of these tactics over the planting duration, something not done elsewhere.

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, pest issues (Magdoff and van Es, 2000), and lower mineralization of nutrients (Forge, 2011). Resulting is the requirement to increase inputs such as fertilizers and can lead to the need for additional tillage activities, thus further increasing soil organic matter losses. Introducing biomass to increase organic matter levels, such as through the use of ground covers, is a common practice in annual production systems.

Over-irrigation can cause leaching of valuable nitrogen fertilizer and can promote root susceptibility to *P. rubi*. Retention of nutrients within the root zone has shown to significantly increase through scheduled-based (tensiomter or atmometer) irrigation (Neilsen et. al 2011).

We will evaluate the use of a set of cultural practices in an integrated fashion so that the individual and combined impacts can be measured. There is no current work being performed with this design or treatments in Idaho, Oregon, or British Columbia.

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

<u>#1 priorities</u>

- Understanding soil ecology and soil borne pathogens and their effects on plant health and crop yields.
- Soil fumigation techniques and alternatives to control soil pathogens, nematodes, and weeds

<u>#2 priorities</u>

- Weed management
- Nutrient/Irrigation management

Objectives:

1. Evaluate integrated measures to improve soil health including use of ground covers, alternative nutrient sources, and more efficient water delivery systems.
2. Evaluate new ground covers to be used in red raspberry production

Procedures: This project is designed to be ongoing through the lifetime of a raspberry planting and will continue for a number of years utilizing similar methods described below, but with the intention of evolving over time.

1. Evaluate integrated measures to improve soil health including use of ground covers, alternative nutrient sources, and more efficient water delivery systems.

The trial was initiated in the spring of 2012 setup in a completely randomized split-split plot design consisting of three replications on two commercial farms in ‘Meeker’ raspberries. Variables include: 1.) Water Use (Tensiometer vs. Timed Irrigation)[Main-plot]; 2.) Ground Covers (No vs. Spring Planted vs. Postharvest planted vs. perennial ground cover [one site only])[split-plot]; and (Organically derived nutrient source vs. synthetic fertilizers [site 1]; spring soil sample driven vs. standard [site 2])[split-split plot]. Spring planted (SP) ground covers will be planted by late April and post-harvest (PH) ground covers will be planted after harvest operations. Ground cover biomass will be taken prior to harvest (Spring-planted only) and in October. Fresh and dry weights will be taken and then samples sent off for nutritional analysis to calculate nutrient contribution. Soil samples will be taken from each split-split plot in late March and nutrient content analyzed, and biological assay (nematode populations, *P. rubi*, *V. dahliae*). Soil temperature sensors (10 cm) will be placed in each sub-plot and soil moisture meters (10 cm) will be placed in each main-plot before irrigation begins along with flow meters. Dormant primocane assessment (diameter) will occur in late winter (Zebarth, Freyman and Kowalenko, 1993) and again in late fall. Chlorophyll content (SPAD 502Plus, Konica Minolta Sensing, Inc.) of leaves will used to assess leaf nitrogen content monthly beginning in April (Privè et al., 1997). In-season assessment of effectiveness of ground cover to suppress weeds will be visually rated (0-100% scale). Fall soil samples will be taken from each split-split plot to measure remaining nutrient content.

2. Evaluate new ground covers to be used in red raspberry production

Continuing work from 2012, additional ground covers (several species and varieties) will be planted in the spring and postharvest of 2013. Ground covers will be evaluated for biomass accumulation, nutrient contribution (through lab analysis), weed suppression, and ability to integrate into commercial systems (evaluating grower preference, costs). Results from this screen will feed into work done on Objective 1 in current and proceeding years.

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 Washington Small Fruit Conference in December. Results will also be published on the WSU Whatcom County website and in the Whatcom Ag Monthly Newsletter along with photos and videos of the process for growers to get a better idea of what is involved throughout the year.

References:

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., 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.

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.

Pinkerton, J. N., Walters, T. W., Windom, G. E., & Bristow, P. R. 2009. Soil Solarization as a Component of an Integrated Program for Control of Raspberry Root Rot [electronic resource]. *Plant disease: an international journal of applied plant pathology*, *93*(5), 452-458.

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

	2013	2014	2015
Salaries[1/]	$2351	$	$
Time-Slip	$	$	$
Operations (goods & services)	$128	$	$
Travel[2/]	$1020	$	$
Meetings	$0	$	$
Other[3/]	$3580	$	$
Equipment[4/]	$2625	$	$
Benefits[5/]	$1032	$	$
Total	**$10736**	**$**	**$**

Budget Justification

[1/] One WSU Whatcom County Extension Personnel at 0.05% FTE ($2,351)

[2/] Travel to and from research sites, 2000 miles at $0.51/mile ($1020)

[3/]Soil Nutrient Analysis ($15/sample-$540); Vert Soil/Plant Sample ($40/sample-$1440); Nematode Bioassay ($20/sample-$720); P. rubi Bioassay ($20/sample-$720); Sample Shipping ($160)

[4/]Includes irrigation fittings for tensiometer-driven irrigation lines ($1025); Soil moisture sensors ($1600). We have asked other researchers at WSU whether this equipment currently exists and could be borrowed. Not listed here are several pieces that will be used that are currently owned by WSU. Information generated from these sensors will give detailed information that can contribute to the overall project, but also directly to the producers.

[5/]Employee benefits for Extension personnel (43.9%) ($1,032).

Current & Pending Support

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:				
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
Benedict, C. McMoran, D. Corbin, A.	WA State Dairy Products Commission	$48,972	1/1/12-12/31/13	5%	Evaluation of Short-Season Silage Corn Varieties
C. Benedict D. McMoran A. Corbin	WA Seed Potato Commission	$36,472	1/1/12-12/31/13	1%	Monitoring for PVY in WA Seed and Ware Potato Production
C. Benedict D. McMoran A. Corbin	WA Potato Commission	$39,862	1/1/12-12/31/13	2%	Monitoring for PVY in WA Seed and Ware Potato Production
Benedict, C. Burrows, C	WA Red Raspberry Commission	$5,921	1/1/12-12/31/12	2%	First Alert Scouting of SWD in Western WA.
Burrows, C. Benedict, C.	WA Red Raspberry Commission	$13,633	1/1/12-12/31/12	5%	Integration of Factors to Improve Soil Health in Red Raspberry Production
Collins, D	Utah State Univ/WSARE	$196,624	10/1/10 – 9/30/13	5.0%	Selecting Management Practices & Cover Crops for

Corbin, A Benedict, C Cogger, C Bary, A	Cascade Harvest Coalition/WSDA	$11,134	10/1/10 – 9/30/13	15%	Reducing Tillage, Enhancing Soil, Quality & Managing Weeds in Western WA Organic Vegetable Farms
Benedict, C		$24,770	5/1/10 - 12/31/12	5%	FarmLink: Reducing Barriers to Farmland Access for Washington's New & Beginning Farmers
Benedict, C. Corbin, A.	WSU-CSANR	$39,838.	1/1/12-12/30/12	0%	Alternative Forage and Fodder Crops for Western Washington Livestock Production
C. Cogger, S.Wayman, C. Benedict, A. Bary A. Corbin	WSU-CSANR				Choosing and managing cover crops to improve weed management in reduced tillage organic vegetable production
Pending: .					

Washington Red Raspberry Commission
Progress Report for 2012 Project

Project No:

Title: First Alert Scouting of SWD in Western WA

Personnel:
Colleen Burrows, Chris Benedict, and Harlan Gough, WSU Whatcom County Extension

Reporting Period:
January to November 2012

Accomplishments:
In May, a workshop was held in Mt. Vernon on identification of Spotted Wing Drosophila, led by Dr. Beverly Gerdeman. This was well attended by growers interested in doing their own scouting. Participants learned and practiced identifying the key features of identifying SWD and how to determine differences between look-alike drosophila.

Selected raspberry fields were scouted for Spotted Wing Drosophila using the clear cup trap with apple cider vinegar bait. The fields were located throughout Whatcom, Skagit, and Pierce Counties with 2-3 traps placed per field. 59 traps in total were monitored from early-June through late-July and the data was posted on the WSU Whatcom County Extension website as the data was collected, where growers could monitor what was happening near their fields. Growers participating in the study received weekly updates on SWD trap counts in their fields. SWD counts were low in most fields and traps throughout the trapping season.
Starting in early July, a trap and bait comparison was set up at 2 locations – a field in Whatcom County and the Northwest Washington Research and Extension Center in Mount Vernon. The traps tested were clear cups, red cups, the commercial Contech trap, and the commercial CAPtiva trap. These traps all used apple cider vinegar as bait. One other treatment of the clear cup using a sugar yeast blend was also tested. Four replications for each were arranged in a randomized complete block design at each location.

Results:
In the SWD scouting program, levels of SWD caught in traps were low or zero in most locations throughout the fruit ripening season. Traps near native tree regions showed higher counts early on, but decreased once treatment began.

The yeast-sugar mix attracted the most SWD of all trap/bait combinations. Some differences were seen between the trap types, but not enough replications were studied to have any statistical significance.

Publications:
Scouting data has been published on the WSU Whatcom County Extension website following each scouting trip. Project reports and data summary will be published on the WSU Whatcom County Extension website by the end of 2012.

2013 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

Project Title: Trap and bait testing for SWD in Northwest Washington Raspberries

PI
Colleen Burrows, WSU Whatcom County Extension,
Agriculture Special Projects Coordinator
1000 N. Forest St. Suite 201,
Bellingham, WA, 98225.
(360) 676-6736
cburrows@wsu.edu

Co-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

Year Initiated 2013 Current Year 2013 Terminating Year 2014

Total Project Request: Year 1 $4,934 Year 2 $ Year 3 $

Other funding sources:
Agency Name: Washington Blueberry Commission
Amt. Requested: $4,934 will be requested for matching work in blueberries.

Description:
Spotted Wing Drosophila (SWD) is a significant direct pest of soft fruit, including red raspberries in Western Washington. In recent years, adult mating and subsequent female ovipositional flight has not begun until well into the raspberry harvest period, generally in late July, indicating a need to more fully understand flight patterns and timing for first treatment. This project will test various traps and trap baits for SWD from May through August and in different locations of the field to determine which combinations are more effective at different times of the year; this will allow for maximization of an on-farm scouting program to accurately determine when SWD will become an issue in a given field and, potentially, to monitor populations after treatment has occurred.

Justification and Background:

Spotted Wing Drosophila (SWD) is a direct pest of red raspberry and has been found in Western Washington soft fruit with later harvests especially impacted. Many growers feel that they have adequate management measures but need to more fully know when to expect SWD.

In 2011 and 2012, WSU Whatcom County coordinated scouting in Northwest Washington so that growers could predict when SWD populations would increase in their fields.

Various trap styles and baits for traps have been evaluated by researchers in other regions, with much of the work being done in Oregon. Initial testing in Northwest Washington shows differences in efficacy between traps and baits. Testing of traps and baits were not tested until July in 2012 in Washington so we were not able to detect preference differences throughout the season. By continuing to test these traps in Northwest Washington throughout the fruit bearing season, and by comparing our data with research done in other regions, we will be able to develop better scouting guidelines improving management decisions.

Relationship to WRRC Research Priority(s):

Life cycle evaluation of SWD is a #1 priority of the Washington Red Raspberry Commission.

Objectives:
Test novel traps and baits for SWD throughout the season.

Procedures:
Test novel traps and baits for SWD throughout the season.
Several traps for SWD are available commercially and new home-made traps are being developed each year. The two most commonly used baits are apple cider vinegar and yeast-sugar that have been tested in Northwest Washington. In collaboration with Amy Dreves from Oregon State University, this project will evaluate several promising traps and bait combinations from May through August (or the end of raspberry harvest) on at least ten farms, including an organic farm and fields suspected of higher SWD populations. Up to 12 bait/trap combinations will be tested on 1-2 farms as a demonstration and 6-8 bait/trap combinations will be tested on all other farms. Four replications of each bait/trap combination will be placed in each field, arranged using a complete randomized block design. Traps will be checked weekly for male and female SWD in each trap.

This work will continue the preliminary work performed in 2012, with a more in-depth study done on different monitoring systems.

Anticipated Benefits and Information Transfer:
This study will give growers improved options to monitor for SWD early in the season and into the raspberry harvest season. If growers are confident with monitoring techniques, they may be able to schedule the first pesticide treatment more closely to SWD biology.

Data will be presented on the WSU Whatcom County Extension web page and at least one field day will be held prior to the start of harvest for growers to observe different traps and give feedback on the pros and cons of each.

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

	2013	**2014**	**2015**
Salaries[1/]	$1,881	$	$
Time-Slip	$1,200	$	$
Operations (goods & services)	$300	$	$
Travel[2/]	$612	$	$
Meetings	$	$	$
Other	$	$	$
Equipment[3/]	$	$	$
Benefits[4/]	$941	$	$
Total	**$4,934**	**$**	**$**

Budget Justification

[1/] One Extension Professional at 8% FTE for six months ($1,881)

[2/] Travel for visits to research fields and field days, 1500 miles at $0.51 per mile ($612)

[3/]No equipment requests

[4/] Employee benefits for extension professional at 43.9% ($826) and for time slip employees at 9.6% ($115)

2013 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

Project Title: Support of USDA-SCRI Proposal "Connecting Raspberry Breeding Programs to Crop Markets through Use of Molecular, Economic and Consumer Science Tools".

PI: Catherine H. Daniels
Organization: WSU
Title: Ext Specialist
Phone:253-445-4511
Email: cdaniels@wsu.edu
Address: 2606 W Pioneer
City/State/Zip: Puyallup, WA 98371

Co-PI: Patrick Moore
Organization: WSU
Title: Research Scientist
Phone:253-445-4525
Email: moorepp@wsu.edu
Address: 2606 W Pioneer
City/State/Zip: Puyallup, WA 98371

Cooperators: (see Appendix A)

Year Initiated __2013__ Current Year _2013_ Terminating Year __2014__

Total Project Request: $1,000

Other funding sources: USDA-SCRI (to be requested in 2013); NABGRF (to be requested in 2012)
Agency Name: Specialty Crop Research Initiative; North American Bramble Growers Research Foundation
Amt. Requested: approximately $2.5M; $1,000

Description:
Our objective is to obtain match funds for a USDA-SCRI research grant we are seeking in 2013; these grants require a 100% match. We are providing portions of the match; however, USDA views match provided directly by industry as an indicator that proposed work is necessary to support industry goals. Accordingly, we are requesting a small portion of the match from the WRRC, contingent upon USDA funding of our proposal. We expect to hear by July 2013 if we are successful. Only after that time would we need access to WRRC funds, if our request here is approved.

The SCRI grant research objectives are (1) identify and test genetic markers specific to horticultural characteristics (e.g. heat tolerance) and pest resistance/tolerance (e.g. aphids, RBDV, nematodes, Phytophthora) in raspberry populations; (2) identify the drivers of liking for raspberry fruit among consumers; (3) identify taste characteristics sought by fruit processors (on behalf of end-use buyers); and (4) identify the price consumers and processors are willing to pay for raspberries having specific taste or health-giving attributes. Altogether, activities designed to meet these four objectives will address stumbling blocks to publically-funded breeding programs (whose goals are to release more cultivars) and to the US red raspberry industry (whose goals are expanded markets and increased grower profitability).

Justification and Background:
In 2011, the USDA Specialty Crops Research Initiative funded us (SCRI grant #2011-51181-30580) along with a number of other co-Project Directors, to develop a roadmap for US raspberry producers, describing how to forge links between new tools for breeding programs and crop markets. This grant was not a traditional research grant, it was planning grant whose purpose is to provide support to develop research grants in close cooperation with industry stakeholders. (If requested, we will be very happy to share the funded proposal with reviewers.)

As part of this planning activity, we hosted two industry-oriented workshops, one at the January 2012 NARBA meeting, and one in Seattle in May 2012. Both were aimed at soliciting input from members of the national raspberry community, including public and private breeders, nursery operations, plant propagators, consultants, growers (fresh and processed fruits), processors, fruit marketers and leaders of commodity organizations.

In addition to collecting information at these workshops we also reviewed research priorities from all industry-based raspberry research foundations, and solicited members of the national raspberry community to join advisory groups which continue to direct our grant work.

We have two results from this work: a list of necessary research steps (aka the roadmap) to further raspberry industry goals, which we would be happy to share on request; and, a USDA-SCRI grant proposal which we intend to submit in January 2013. This SCRI traditional research proposal will address two needs brought up numerous times by stakeholders: the need for more cultivars that have specific traits of interest (for use in diverse areas around the US); and, research-based information about what drives "liking" for raspberry fruit among consumers.

Although the research proposal will not address all of the needs voiced by the raspberry industry, it will address two key areas. The limitations on public breeders now are the lack of molecular tools which would help them cut down on field testing new cultivars, and a knowledge of which characteristics consumers want in their raspberry fruit. By picking a few traits to use as test cases in developing new molecular tools, a process can be established whereby more traits can follow. This will cut down on the 14-year average release time for new PNW cultivars. Similarly, by quantifying the fruit characteristics (what feature and how intense) that cause consumers to like or dislike raspberries, the breeders will be able to incorporate these measurements into their selection regime. We are proposing a fruit auction as part of an economic assessment to determine what price consumers are willing to pay for fruit with the attributes they most favor. Such information would be valuable to growers in regional markets who are facing decisions on replanting and fruit marketing.

Relationship to WRRC Research Priority(s):

This work addresses #1 priority:

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

Procedures:

- We have all publically-funded red raspberry breeders in the US involved in this project. They will make red raspberry crosses, grow the progeny in WA, NY and NC, and observe them for phenotypic characteristics.
- We have also assembled a team of molecular biologists who will sequence DNA from those red raspberry crosses and identify markers for specific traits (e.g., RBDV resistance, heat tolerance, aphid resistance, etc.) based on phenotypic information supplied by the breeders.
- Our consumer team will use commercial sources for red raspberry fruit in order to set up regional taste panels, design and implement national surveys, and, with the economic team, set up regional fruit auctions to determine the price consumers would pay for fruit with the flavor, texture or nutraceutical benefits they most favor.
- If successful with securing USDA-SCRI funding, we expect to begin the project in July 2013 and continue until the grant end date of December 31, 2018. Seedlings will go to propagation in July 2013, then into phenotype testing during 2014 - 2018. Sequencing will begin in early 2014 and be followed by gene mapping which will continue through 2018. Consumer/Economic work will begin in July 2013 and continue until 2018.

Anticipated Benefits and Information Transfer: (100 words maximum)

- Growers in regional markets who are facing replanting and other fruit marketing decisions will have access to information about fruit characteristics that consumers in their region want.
- This work will lead to a shorter average release time for new PNW cultivars.
- Information derived from these grant activities will be shared with the industry through specific advisory board members, field days, meeting seminars, newsletters, etc.

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

	2013	**2014**	**2015**
Salaries[1/]	$	$	$
Time-Slip	$1,000	$	$
Operations (goods & services)	$	$	$
Travel[2/]	$	$	$
Meetings	$	$	$
Other	$	$	$
Equipment[3/]	$	$	$
Benefits[4/]	$	$	$
Total	**$**	**$**	**$**

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. (See attached sheet for GRA rates, which is based on latest OGRD matrix for assistantships.)

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:				
	Pending:				

2012 PROGRESS REPORT

Title: Red Raspberry Cultivar Development

Personnel: Chaim Kempler, Research Scientist, Michael Dossett, Visiting Fellow, Plant Geneticist
Brian Harding 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, Chaim.Kempler@agr.gc.ca Tel: 604-796-1716 Fax: 604-796-0359 cell: 604-819-0175

Summary:
In 2012, the PARC program evaluated two machine-harvested and two hand-harvested plots at the Clearbrook substation. This was tremendously successful at providing critical information on machine-harvestability of fruit, particularly with regards to whether fruit tend to crumble, harvest when overripe, or collapse into mush in response to machine harvesting. We plan to continue this in the future for all our replicated plots at the substation and machine-harvest raspberry seedlings in 2013. In addition, we ran 17 root rot screens in the greenhouse, evaluating selections and germplasm for root rot resistance, identified 7 biotypes of the raspberry aphid, and began constructing genetic linkage maps for populations representing new sources of aphid resistance, *Phytophthora* root rot resistance, and *Raspberry bushy dwarf virus* resistance.

Machine-harvested Trials
Two machine-harvested trials were run in 2012 at the Clearbrook substation. The first was a replicated yield trial of 3-plant plots planted in 2008 (Table 1). These plots were hand-harvested for the first two years. We decided to machine-harvest these plots to examine the feasibility of machine-harvesting small plots and also to compare yield and other data with previous years. While one year is not enough to make a judgment on the full potential of this method and plot size, the crumbliness of the fruit was very consistent from harvest to harvest, which will allow us to focus much more closely on machine-harvested fruit quality. This field has been removed, but we will be using this method of evaluation in our other 3-plant replicated plots next year.

The second machine-harvest trial consisted of non-replicated 112 plots of 10 plants each. This was the baby-crop year for this field and many of the plots did not establish well, but we were still able to evaluate how well fruit came through the process of machine-harvesting. Those selections which were either high yielding or machine-harvested well are summarized in Table 2. Several of these selections have already been slated for trials on either grower sites or from other breeding programs. In addition, four selections which were noted for good machine-harvestability were planted at the WRRC-sponsored machine harvest trial site at Randy Honcoop's farm in Lynden Washington earlier this year. This field will be evaluated again in 2013.

Hand-picked Yield Trials:
Yield trials planted in 2009 and 2010 were harvested by hand at the Clearbrook substation in Abbotsford, BC. Most of the plots in these experiments were non-replicated because not enough plants were available to plant larger trials. This was the second year that the 2009 field was harvested, and with the exception of BC 93-15-40, not many of the selections stand out (Table 3). The 2010 yield trial was harvested for the first time in 2012 and includes a number of selections from the AAFC breeding program in Kentville, Nova Scotia (Table 4).

Other Projects:
In 2012, we finished work confirming the presence of 6 biotypes of the raspberry aphid *Amphorophora agathonica* in SW British Columbia (Biotypes A-F, Table 5) and have tentatively identified a seventh (Biotype G). In addition, we have identified three sources of resistance, each from wild North American red raspberry, that hold up to these aphid biotypes. So far the data suggest that two of them (BC 90-19-34 and BC 93-16-43) are controlled by single dominant genes. The important messages from this work are: 1.) We need to identify more sources of resistance if aphid resistance for virus control is going to remain a realistic breeding target, and 2.) Aphids will continue to evolve and adapt to new resistance genes until we change the approach for selecting for aphid resistance - it will probably be necessary to pyramid resistance genes in order to continue development of cultivars with durable aphid resistance. A publication describing this work in detail has been accepted by the Journal of the American Society for Horticultural Science and is In Press.

For the last few years, the breeding program has been working in collaboration with Tom Forge to develop a semi-hydroponic method for screening raspberry selections and germplasm for resistance to *Phytophthora* root rot. At the end of each 4-week trial, the roots are washed and both roots and shoots are subjectively rated for disease symptoms. Last winter/spring we ran 17 separate evaluations. This season, we plan to run ~20 root rot trials with approximately 8 plants each of 10 different genotypes along with resistant and susceptible standards in each trial. Preliminary data quantifying *Phytophthora* infection using PCR has correlated strongly with visual ratings of roots, and much less strongly with either above-ground symptoms or root mass. There has been essentially no correlation between degree of *Phytophthora* infection of the roots with shoot mass.

Beginning in late 2011, the breeding program began project to develop and map genetic markers in red raspberry with the idea of correlating these markers to important traits for use in breeding. More than 6,200 simple sequence repeat (SSR) markers were identified. In early 2012 we began validation of 384 of these markers and plan to work to validate an additional 480 SSR markers in the coming months. These same markers are also being mapped in black raspberry in collaboration with Dr. Nahla Bassil in Corvallis, Oregon, with the idea that having identical mapped markers in red and black raspberry will facilitate efforts to transfer traits of interest from one species to the other during breeding. For example, new sources of aphid resistance and fruit rot resistance from black raspberry to red raspberry and aphid resistance and thornlessness from red raspberry to black raspberry. These markers will be mapped in two red raspberry populations (BC 90-19-34 x Malahat, and BC 93-16-43 x Malahat). The seedlings in these populations have already been screened for aphid resistance and have led to the discovery of two sources of resistance which have not yet been broken. We are now beginning to screen these populations for segregation of root rot resistance. Evaluation of resistance to *Raspberry bushy dwarf virus* will begin after the plants have been established in the field. We expect to finish marker validation in early 2012 and begin linkage map construction at that time.

Notes recent variety releases and selections available for testing:

Chemainus [(Algonquin x Chilliwack) x Tulameen): A mid-season processing and fresh market type that produces attractive, large-sized, medium-dark colored berry. Chemainus produces high quality fruit that machine harvests very well and can be used for processing and IQF. The fruit is glossy, large, and firm, with a nice conical shape and medium to fine drupelets. It is well-suited to IQF and also fresh market production. The plant has excellent vigor, producing plenty of replacement canes. Its primocanes are green with no spines and laterals are short and strong with a good upright angle and well spaced fruit. It is not resistant to RBDV. Chemainus appears to show some degree of field resistance to root rot induced by *P. rubi* showing good growth in comparison to Meeker and Malahat. Chemainus has been planted widely in the PNW with large acreages in production (yield data is presented in the tables).

Saanich [(Algonquin x Chilliwack) x (Nootka x Glen Prosen)]: A promising release from the PARC breeding program that is very productive, producing very high yields with a fruit size that is slightly larger than Meeker and is suited for the fresh or processing markets. The excellent quality fruit are firm with medium gloss, very fine drupelets and low acidity. The fruit IQFs extremely well, holding its shape with no breakage. The canes are spineless with laterals that are short and bend easily without breaking and so are able to carry the high yield. In large growers' trials, the fruit released well from the receptacle and harvested very well mechanically. This variety, although exposed to high pressure of RBDV for many years, has been very slow to show RBDV infection. It was released because of its productivity, suitability for machine harvesting and exceptionally high fruit quality that is suited for IQF. It produces fruit that is large to medium-sized, medium red color, and firm.

Ukee (Chilliwack x BC 86-41-15): Ukee is a new floricane-fruiting red raspberry cultivar from the PARC breeding program. Ukee produces a high yield of large, firm fruit suited for the fresh market. It machine harvests well and may IQF but is too light for puree or other outlets. Ukee exhibits an excellent degree of field and greenhouse resistance to root rot caused by *P. rubi*. Ukee, tested as BC 92-6-41, was selected from a 1992 cross Chilliwack, and selection BC 86-41-15. BC 86-41-15, comes from a 2nd back cross from the North American wild raspberry *R. strigosus* (the Dalhousie Lake 4 clone). Ukee floricanes are straight and strong. They are thinner than those of Tulameen, and Chemainus, but similar to those of Saanich and Meeker. The canes are noticeably shorter than most other varieties but are still long enough for use in a 'looped' trellis system. Ukee laterals are long and strong and carry the yield very well; fruit is spread on the laterals and is well presented. Ukee fruit have a nice conical shape and the fruit are medium to large with small drupelets. Fruit colour is medium to light red with low gloss and a dusty appearance. Ukee is productive and maintains good fruit size over its long harvest season. The fruit colour is lighter than that of Meeker; it is acceptable for IQF and possibly for other types of processing where dark pigment is not required. In machine harvest trials Ukee rated as suitable for machine harvesting, giving good fruit quality that is suited for IQF. In IQF trials it appears acceptable, but more testing is needed. The ripening season for Ukee is similar to that of Meeker. Because of its long laterals, Ukee fruit is exposed and therefore easy to hand harvest. The fruit size is larger than that of Meeker. Ukee was selected for resistance conferred by the Ag_1 gene to the common biotype of *A. agathonica*, the N. American large raspberry aphid vector of the RMV complex, and it has tested negative to RMV ever since the genotype was selected. It has exhibited a high degree of field resistance to root rot caused by *P. rubi* and under extreme root rot pressure at WSU Puyallup it did not show symptoms. While not resistant to spur blight, (*Didymella applanata*), Ukee has been rated as less susceptible than Meeker, Malahat, Chemainus or Tulameen. Ukee, Meeker, Saanich and Malahat have similar (low) susceptibility to cane Botrytis (*B. cinerea*) and show more resistance than Tulameen or Chemainus. Ukee is moderately susceptible to anthracnose (*Elsinoe veneta*), having a response similar to Meeker.

Rudi (BC 86-41-15 x Qualicum): Rudi is a new floricane-fruiting red raspberry cultivar from the PARC breeding program. Rudi produces a high yield of firm, large fruit that mature early, machine harvest very well, and are suited for processing and the fresh market. It was named after Mr. Rudi Janzen on whose field this cultivar was tested. Mr. Janzen played an important part in the testing and evaluation processes of the cultivar. Rudi tested as BC 90-4-23, was selected from a 1990 cross of the PARC released cultivar, Qualicum, and selection BC 86-41-15. Qualicum was selected from a cross between the SCRI cultivar Glen Moy and Chilliwack. The other parent, BC 86-41-15, comes from a 2nd back cross from the North American wild raspberry *R. strigosus* (the Dalhousie Lake 4 clone). Rudi floricanes are straight, strong, and thinner than those of Tulameen, Malahat and Chemainus but similar to those of Saanich and Meeker. When selected in 1994 from a single plant, it was noted as being early ripening with long laterals, attractive appearance, nice flavor, firm fruit just over 4 g, only a few spines, and easy to harvest. Rudi laterals are long and strong and carry the yield very well; fruit is spread on the laterals and is well presented. Rudi fruit have an excellent appearance; fruit are medium to large in size and conical with medium size drupelets. Fruit colour is medium to dark red with high gloss. Rudi is productive and maintains a good fruit size over its harvesting season. The fruit colour is similar to that of Meeker; it is acceptable for processing where dark pigment is required. It machine harvests very well with harvest starting a few days before Meeker and ending almost a week before Meeker. While not resistant to spur blight (*Didymella applanata*), Rudi has been rated as less susceptible than Meeker, Malahat, Chemainus or Tulameen. Rudi, Ukee, Meeker, Saanich and Malahat have similar (low) susceptibility to cane Botrytis (*B. cinerea*) and show more resistance than Tulameen or Chemainus. Rudi is moderately susceptible to anthracnose (*Elsinoe veneta*), having a response similar to Meeker. Rudi is a multi-purpose cultivar that is suited for machine harvesting/processing and the fresh market.

BC 90-8-11 (BC 86-41-24 x Qualicum): This is a 3rd backcross from a *R. strigosus* Dalhousie Lake 4 clone. It produces large mid-to-late season crop that is suited for the fresh and processing markets. The fruit is large (5.5 g) and meaty, light red in color, glossy, firm, conical in shape and very attractive. The plant has a good vigor with light green foliage an upright habit and producing enough replacement canes. The fruit is well spaced and presented on the laterals. It is susceptible to RBDV and moderately susceptible to cane diseases. It is resistant to aphids.

BC 90-8-20 (BC 86-41-24 x Qualicum): A productive mid-season selection that produces very large long meaty fruit (5.9 g) that is a dull light red in color and most suitable for the fresh market. This selection is not suited for mechanical harvesting. The large, low-gloss fruit strongly resembles Qualicum. Plant vigor is not excessive with leaves that are large and light green color, laterals are long. It does not appear to be field resistant to root rot. It is susceptible to RBDV and moderately susceptible to cane diseases.

BC 90-11-44 (Algonquin x Qualicum): This is a very productive selection that produces over an extended harvest season. The attractive fruit is large, glossy, and firm, with very fine drupelets and producing a high early to mid season yield. It is easy to harvest and performed well in mechanical harvesting trials. The fruit is suited for processing, IQF and fresh markets. This selection is not resistant to RBDV and is relatively susceptible to root rot.

BC 92-5-47 (Kitsilano x BC 86-40-6): A productive selection producing mid-size fruit. It originates from a 3rd back cross from *R. strigosus*. It has performed well in MH trials and has begun testing on larger trials. The fruit is medium size (3.8 g) dark, firm and round shaped with fine drupelets but appears to be not suited for IQF processing but because of its dark color it may be suited as Willamette replacement. The fruit has excellent flavor that is very aromatic and has good acidity. It is not resistant to RBDV but has above average field resistance to root rot. The plant is productive with strong laterals. It produces an earlier crop than Meeker.

BC 92-9-15 (Malahat x BC86-41-15): This selection produces large fruit that matures early and is suited for the fresh and the processing markets. It stands very well to root rot and machine harvests very well. In machine harvest and fresh market grower trials it was identified as having the potential of replacing Malahat because of its fruit quality, root rot tolerance, earliness and machine harvestability. It produces attractive, glossy, medium dark, large, very firm fruit with medium to large drupelets. The fruit has good post-harvest quality and is accepted very well by the consumers because of its attractive appearance, good aroma and flavor. It is a 3rd backcross from *R. strigosus* the Dalhousie Lake 4 clone via Skeena, Meeker, Comox and Malahat. It is susceptible to spur blight and RBDV. After some delays because of slow propagation, BC 92-9-15 will be officially named later this year.

BC 96-22R-55 [(Tulameen x *R. strigosus*) x (Cherokee x Qualicum)]: This selection is from a 1st back cross from *R. strigosus*, collected from 8th Lake State Park Campground, Adirondack State Park, NY. The parents were selected because of their resistance to root rot. In machine harvesting trials, it harvested very well, producing fruit that is darker red than Meeker and may be suitable replacement to Willamette. The fruit is attractive and large (4.7g). It has round, barrel-shaped fruit with large, coarse drupelets and a glossy red color. The plant growth habit is well adapted for machine harvesting, with short, strong, upright laterals and good vigor. The harvest season of this selection starts later than Meeker and is short and concentrated. In greenhouse trials it tested as highly resistant root rot and also stands very well in several field tests. It tested positive to RBDV in 2009 after more than 10 years of exposure to the virus in the field; it is possible that it will be slow in getting infected. It is moderately tolerant to cane diseases.

BC 97-30-27 (Qualicum x Willamette): In the machine harvesting trial, this selection harvested well. The fruit size is larger and the color is darker than Meeker; the fruit is firm with small, fine drupelets. Because of its dark color it may be a good replacement for Willamette as it is higher yielding and stands better to root rot than Willamette. The fruiting season is earlier than Meeker and more similar to Willamette. It is not resistant to RBDV.

BC 1-61-38 (BC 90-19-34 x Glen Magna) Extremely late, finished flowering in late July, fruit ripens into September. It has good fruit quality and ripens later than Octavia. Fruit is dusty, meaty but only moderately firm with an average size of 3.7 g and very high yields. Canes are very thorny. BC 1-61-38 may be tolerant to root rot. It is susceptible to RBDV, and moderately susceptible to cane diseases.

BC 3-14-12 (Cowichan x Esquimalt) Very productive selection probably best suited for the fresh market because of its light colour. It ripens almost a week later than Meeker and produces large fruit with thick meaty druplets. It is resistant to RBDV and susceptible to cane diseases.

A limited number of plants from this list will be available for trials from PARC Agassiz and from the PNW propagators. You are encouraged to plant and test some of these experimental trial selections. To receive trial plants contact Chaim Kempler by email: chaim.kempler@agr.gc.ca

Table 1. Yield and fruit weight of hand-harvested (in 2010 and 2011) and machine-harvested (2012) raspberry cultivars and selections planted in 2008 in Abbotsford, BC.

Clone	**Reps**	**Total yield (kg/hill)**			**Marketable yield (tons/ac)**			**Fruit weight (g)**			**Machine harvestable yield (%)**	**Green fruit (g)**
		2010	**2011**	**2012**	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**		
BC 1-16-8	3	--[z]	--	3.81	--	--	6.11	--	--	3.3	--	156
BC 1-17-1	*3*	*4.00*	*--*	*3.74*	*6.41*	*--*	*6.00*	*4.8*	*--*	*4.0*	*93.6*	*166*
BC 1-88-6	*3*	*4.18*	*3.30*	*1.72*	*6.69*	*5.29*	*2.76*	*4.7*	*4.4*	*3.6*	*46.1*	*197*
BC 3-19-5	1	--	3.13	2.46	--	5.01	3.93	--	3.3	3.3	78.5	71
BC 3-19-8	1	1.70	2.59	1.73	2.72	4.15	2.77	3.2	3.6	3.2	80.6	54
BC 4-13-46	*3*	*2.40*	*2.56*	*2.81*	*3.84*	*4.11*	*4.49*	*4.3*	*4.0*	*4.4*	*113.0*	*191*
BC 4-13-7	*3*	*2.98*	*3.82*	*2.74*	*4.77*	*6.12*	*4.39*	*5.1*	*5.3*	*4.8*	*80.6*	*221*
BC 4-22-91	1	2.67	3.82	1.95	4.28	6.12	3.12	2.9	3.7	2.7	60.1	142
BC 4-36-17	*1*	*2.70*	*3.55*	*2.94*	*4.33*	*5.69*	*4.71*	*3.3*	*3.8*	*3.2*	*94.1*	*139*
BC 4-4-11	*1*	*2.68*	*2.32*	*1.54*	*4.30*	*3.72*	*2.47*	*4.6*	*5.2*	*4.3*	*61.6*	*317*
BC 4-41-11	1	2.83	3.27	0.75	4.54	5.24	1.20	3.6	3.8	2.7	24.6	6
BC 4-41-58	1	--	2.14	1.16	--	3.43	1.86	--	3.3	3.2	54.1	39
BC 4-41-6	1	--	2.86	1.26	--	4.59	2.01	--	3.2	2.4	43.9	28
BC 4-41-8	2	4.39	3.70	1.61	7.03	5.93	2.58	4.2	4.2	3.4	39.8	110
BC 4-41-87	1	2.76	4.65	2.59	4.42	7.45	4.14	4.7	5.3	4.4	69.8	183
BC 4-42-59	3	3.54	4.33	2.09	5.67	6.93	3.35	4.2	4.7	3.6	53.2	125
BC 4-42-76	1	2.84	4.66	2.76	4.54	7.46	4.42	4.2	4.2	3.6	73.6	162
BC 4-46-59	1	3.18	2.13	2.23	5.09	3.41	3.57	3.9	4.0	3.4	83.8	94
BC 4-65-3	1	3.36	3.02	1.36	5.38	4.84	2.18	2.8	3.6	2.7	42.7	51
BC 4-66-16	1	2.62	2.25	0.72	4.20	3.60	1.15	3.9	4.2	3.5	29.6	30
BC 4-67-4	*1*	*2.71*	*3.51*	*1.66*	*4.35*	*5.62*	*2.67*	*3.0*	*3.1*	*3.3*	*53.5*	*19*
BC 4-93-2	3	3.56	3.95	2.81	5.70	6.33	4.51	5.1	5.5	4.6	74.9	235
BC 90-19-8	2	--	3.25	1.84	--	5.20	2.95	--	3.7	3.2	56.8	38
BC 90-5-30	3	2.68	3.11	3.10	4.30	4.98	4.97	4.3	4.7	3.9	107.2	99
BC 92-5-47	2	3.05	2.26	1.39	4.89	3.63	2.23	4.2	3.6	3.0	52.3	34
BC 96-17R-45	1	2.54	3.85	2.03	4.07	6.17	3.25	3.8	4.1	3.3	63.5	202
C. Bounty	3	3.06	3.41	1.45	4.91	5.46	2.32	3.1	3.0	2.6	44.8	43
Chemainus	*4*	*3.63*	*3.46*	*2.83*	*5.82*	*5.54*	*4.53*	*3.6*	*4.1*	*3.5*	*79.8*	*93*
Jeanne d'Orleans	*3*	*2.83*	*2.53*	*1.41*	*4.53*	*4.06*	*2.26*	*3.2*	*3.0*	*2.5*	*52.5*	*62*
Malahat	3	3.14	3.46	1.65	5.02	5.54	2.64	4.0	4.2	3.4	50.0	28
Meeker	3	3.67	3.31	1.89	5.87	5.31	3.03	3.1	3.1	2.8	54.1	71
Saanich	*3*	*5.03*	*3.83*	*1.89*	*8.06*	*6.13*	*3.02*	*3.4*	*3.0*	*2.5*	*42.6*	*63*
Tulameen	3	2.94	2.62	1.87	4.72	4.20	3.00	4.1	3.9	3.2	67.3	25
WSU 1447	*3*	*2.60*	*2.46*	*2.16*	*4.16*	*3.93*	*3.46*	*3.4*	*3.8*	*3.4*	*85.4*	*81*
WSU 1499	*2*	*2.56*	*2.65*	*1.73*	*4.10*	*4.24*	*2.78*	*2.3*	*2.4*	*2.2*	*66.6*	*12*
LSD[y]		**1.25**	**1.06**	**0.93**	**2.00**	**1.69**	**1.50**	**0.8**	**0.8**	**0.6**		**67**

Plants were grown in hills with spacing of 3ft between the plants and row spacing of 10ft (3588 plants/ha). Plants were pruned to 6 canes per hill and looped at the top of the trellis. Italicised entries noted for fruit holding up particularly well to machine-harvesting.

[z] Not all plots harvested in every year.

[y] Data from replicated plots subjected to ANOVA with least significant difference (LSD) of 5%

Table 2. Yield, fruit size, and length of harvest, for top-performing selections and standard cultivars during 2012 in the 2010-planted machine-harvest trial at the Clearbrook substation, Abbotsford, BC.

Clone	Canes/hill (number)	Total yield (g/cane)	Total yield (kg/hill)	Fruit Weight (g)	5% Harvest (date)	50% Harvest (date)	95% Harvest (date)	Harvest Duration (days)	Green fruit (g)
BC 5-11-1[z]	*10.9*	*61*	*0.67*	*2.8*	*10-Jul*	*20-Jul*	*07-Aug*	*29*	*24*
BC 5-12-7	*9.3*	*150*	*1.39*	*5.1*	*09-Jul*	*18-Jul*	*02-Aug*	*25*	*165*
BC 5-18-38	6.1	134	0.82	4.2	08-Jul	16-Jul	30-Jul	23	141
BC 5-21-18	*10.6*	*86*	*0.91*	*4.3*	*10-Jul*	*22-Jul*	*09-Aug*	*31*	*87*
BC 5-2-16	*9.4*	*132*	*1.24*	*3.6*	*12-Jul*	*23-Jul*	*09-Aug*	*29*	*116*
BC 5-24-12	8.4	200	1.68	3.7	11-Jul	19-Jul	05-Aug	26	134
BC 5-34-24	*11.0*	*129*	*1.42*	*3.7*	*12-Jul*	*22-Jul*	*09-Aug*	*29*	*130*
BC 6-20-60	8.7	135	1.17	4.1	09-Jul	19-Jul	03-Aug	26	147
BC 6-22-35	*7.0*	*296*	*2.08*	*3.2*	*15-Jul*	*29-Jul*	*10-Aug*	*27*	*490*
BC 6-22-44	*7.8*	*203*	*1.59*	*3.9*	*12-Jul*	*21-Jul*	*03-Aug*	*23*	*159*
BC 6-25-50	8.7	146	1.27	4.1	09-Jul	17-Jul	01-Aug	24	151
BC 6-27-41	*11.5*	*175*	*2.01*	*3.9*	*10-Jul*	*22-Jul*	*09-Aug*	*31*	*400*
BC 6-36-10	*8.0*	*113*	*0.90*	*4.2*	*09-Jul*	*20-Jul*	*06-Aug*	*29*	*154*
BC 6-50-41	*8.4*	*197*	*1.66*	*3.3*	*11-Jul*	*22-Jul*	*10-Aug*	*31*	*131*
BC 6-50-44	*9.8*	*150*	*1.47*	*3.3*	*10-Jul*	*21-Jul*	*08-Aug*	*30*	*77*
BC 6-51-32	11.4	180	2.05	4.4	15-Jul	27-Jul	09-Aug	26	270
BC 6-63-24	*10.4*	*33*	*0.34*	*3.1*	*08-Jul*	*16-Jul*	*31-Jul*	*24*	*16*
BC 6-64-75	*10.6*	*167*	*1.77*	*4.1*	*11-Jul*	*23-Jul*	*08-Aug*	*29*	*111*
BC 6-64-94	7.5	130	0.97	4.3	11-Jul	17-Jul	31-Jul	21	69
BC 6-66-19	*7.6*	*156*	*1.19*	*5.2*	*11-Jul*	*22-Jul*	*09-Aug*	*30*	*54*
BC 6-69-25	8.8	164	1.44	4.8	16-Jul	29-Jul	10-Aug	26	148
BC 6-84-41	11.2	157	1.76	4.1	11-Jul	19-Jul	02-Aug	23	103
BC 6-84-9	10.2	185	1.88	3.9	13-Jul	24-Jul	09-Aug	28	114
BC 6-89-18	9.3	138	1.28	4.1	14-Jul	26-Jul	10-Aug	28	178
BC 6-89-3	3.5	217	0.76	4.7	14-Jul	24-Jul	10-Aug	28	110
BC 90-12-50	7.6	124	0.94	3.5	11-Jul	19-Jul	05-Aug	26	154
BC 93-15-38	5.5	131	0.72	3.5	17-Jul	29-Jul	09-Aug	24	158
BC 96-22R-55	11.4	94	1.07	4.0	14-Jul	24-Jul	09-Aug	27	154
C. Bounty	9.5	153	1.46	3.6	10-Jul	18-Jul	05-Aug	27	165
Chemainus	*10.6*	*125*	*1.32*	*4.0*	*10-Jul*	*22-Jul*	*04-Aug*	*26*	*159*
Meeker	2.3	195	0.45	3.3	14-Jul	22-Jul	10-Aug	28	70
Rudi	4.4	208	0.92	3.5	08-Jul	16-Jul	31-Jul	24	58
Saanich	*7.4*	*175*	*1.29*	*3.3*	*14-Jul*	*23-Jul*	*10-Aug*	*28*	*197*

Plants were grown in hills with spacing of 3ft between the plants and row spacing of 10ft (3588 plants/ha). Only the top yielding selections and those noted for holding up well to machine-harvest are shown.

[z] Italicized entries represent selections noted for fruit holding up well to machine-harvesting.

Table 3. Harvest data for hand-harvested raspberry yield trial planted in 2009 and harvested in 2012 at Abbotsford, BC.

Clone	Total yield (kg/hill)	Fruit rot (%)	Fruit weight (g)	5% Harvest (date)	50% Harvest (date)	95% Harvest (date)	Harvest duration (days)
BC 1-3-13	1.86	8.5	2.4	07-Jul	19-Jul	04-Aug	29.3
BC 1-86-7	2.55	33.4	4.3	13-Jul	23-Jul	03-Aug	22.0
BC 2-2-12	3.01	9.0	4.3	07-Jul	17-Jul	31-Jul	25.0
BC 2-2-67	2.19	15.9	4.1	12-Jul	27-Jul	11-Aug	31.5
BC 2-35-34	3.38	6.6	4.0	08-Jul	20-Jul	11-Aug	35.5
BC 5-11-1	1.37	18.1	3.2	09-Jul	23-Jul	09-Aug	32.0
BC 5-12-72	2.96	9.6	4.4	06-Jul	15-Jul	29-Jul	23.5
BC 5-12-79	3.47	6.8	3.6	03-Jul	13-Jul	02-Aug	31.0
BC 5-13-23	1.68	27.5	3.4	11-Jul	21-Jul	03-Aug	24.0
BC 5-13-90	2.10	17.4	3.0	02-Jul	11-Jul	30-Jul	28.5
BC 5-17-72	2.52	17.4	3.0	02-Jul	11-Jul	30-Jul	28.5
BC 5-18-38	2.28	4.6	3.4	06-Jul	17-Jul	30-Jul	25.5
BC 5-2-12	2.02	2.7	2.9	04-Jul	13-Jul	30-Jul	27.0
BC 5-21-25	2.39	27.9	2.5	04-Jul	17-Jul	13-Aug	41.0
BC 5-24-12	2.83	6.3	3.7	12-Jul	23-Jul	10-Aug	30.5
BC 5-24-22	2.07	17.3	3.4	04-Jul	14-Jul	31-Jul	28.0
BC 5-34-24	2.79	17.3	3.9	10-Jul	21-Jul	09-Aug	31.5
BC 5-9-10	1.78	7.8	2.8	07-Jul	27-Jul	15-Aug	40.0
BC 93-15-40	6.77	13.1	4.1	07-Jul	17-Jul	30-Jul	24.0
BC 93-9-48	2.05	12.3	3.5	10-Jul	23-Jul	06-Aug	27.5
BC 96-17R-45	2.58	12.8	4.2	10-Jul	20-Jul	02-Aug	24.5
C. Bounty	1.31	6.5	1.7	04-Jul	15-Jul	29-Jul	26.5
Chemainus	3.07	15.7	3.7	09-Jul	23-Jul	09-Aug	32.0
Malahat	3.71	11.1	3.1	02-Jul	11-Jul	30-Jul	29.2
Meeker	2.64	5.8	3.1	10-Jul	22-Jul	04-Aug	25.7
Rudi	4.07	6.4	3.6	03-Jul	13-Jul	04-Aug	33.0
Saanich	4.43	10.3	3.2	12-Jul	25-Jul	10-Aug	30.2
Tulameen	2.76	9.5	3.8	10-Jul	22-Jul	09-Aug	30.7
Ukee	1.98	7.2	3.3	11-Jul	22-Jul	05-Aug	26.5

Table 4. Harvest data for hand-harvested raspberry yield trial planted in 2010 and harvested in 2012 at Abbotsford, BC.

Clone	Total yield (kg/hill)	Fruit rot (%)	Fruit weight (g)	5% Harvest (date)	50% Harvest (date)	95% Harvest (date)	Harvest duration (days)
BC 1-61-38	1.88	22.3	3.6	01-Aug	08-Aug	19-Aug	19.0
BC 5-24-13	3.38	15.4	3.1	06-Jul	19-Jul	05-Aug	30.5
BC 5-7-51	1.81	28.7	3.3	07-Jul	22-Jul	10-Aug	34.5
BC 6-3-39	3.53	23.9	3.6	08-Jul	22-Jul	07-Aug	31.0
BC 6-31-13	2.56	7.2	3.8	07-Jul	17-Jul	30-Jul	24.0
BC 6-31-2	2.31	8.6	2.7	02-Jul	10-Jul	27-Jul	26.0
BC 6-32-13	2.29	20.0	4.3	09-Jul	26-Jul	12-Aug	35.5
BC 6-32-5	3.17	17.4	4.5	11-Jul	24-Jul	13-Aug	34.0
BC 6-36-12	1.79	13.6	2.0	02-Jul	08-Jul	22-Jul	21.0
BC 6-38-33	4.17	22.3	4.2	03-Jul	18-Jul	05-Aug	34.5
BC 6-38-52	1.72	17.9	3.3	07-Jul	22-Jul	07-Aug	31.5
BC 6-4-60	4.10	18.3	3.1	03-Jul	20-Jul	15-Aug	44.0
BC 6-40-16	2.22	7.1	5.1	10-Jul	21-Jul	11-Aug	32.5
BC 6-42-12	3.02	11.8	2.4	02-Jul	09-Jul	25-Jul	23.5
BC 6-42-22	4.07	15.5	3.6	04-Jul	16-Jul	29-Jul	26.0
BC 6-42-33	2.67	30.8	4.0	08-Jul	19-Jul	02-Aug	26.0
BC 6-6-54	3.37	7.3	4.0	03-Jul	15-Jul	29-Jul	27.0
BC 6-6-7	4.01	16.8	4.5	10-Jul	22-Jul	06-Aug	28.5
BC 6-64-115	3.06	22.5	3.5	05-Jul	19-Jul	03-Aug	30.0
BC 6-64-37	3.27	16.5	3.1	03-Jul	14-Jul	29-Jul	27.0
BC 6-66-13	4.81	7.9	4.5	13-Jul	26-Jul	12-Aug	31.0
BC 6-67-3	2.86	20.3	4.5	11-Jul	23-Jul	10-Aug	31.0
BC 6-70-10	1.79	9.1	3.7	03-Jul	14-Jul	23-Jul	21.5
BC 6-74-16	3.56	21.9	4.5	06-Jul	20-Jul	08-Aug	33.5
BC 6-75-11	2.24	11.9	2.6	06-Jul	19-Jul	30-Jul	25.0
BC 6-75-32	3.84	27.4	3.8	05-Jul	21-Jul	05-Aug	32.0
BC 6-75-36	2.68	16.9	4.6	07-Jul	19-Jul	29-Jul	23.0
BC 6-81-36	3.03	8.8	3.7	07-Jul	16-Jul	27-Jul	21.5
BC 6-83-15	1.12	9.2	3.3	07-Jul	19-Jul	30-Jul	24.0
BC 6-83-26	3.17	8.1	4.1	04-Jul	19-Jul	29-Jul	25.5
BC 6-89-11	1.45	18.7	5.5	12-Jul	25-Jul	17-Aug	36.5
BC 96-22R-55	1.54	14.4	3.5	11-Jul	21-Jul	03-Aug	23.8
K02-11	3.22	9.2	4.1	13-Jul	25-Jul	10-Aug	29.0
K02-12	2.83	6.0	3.4	03-Jul	18-Jul	30-Jul	28.5
K02-14	3.34	8.8	3.4	03-Jul	16-Jul	30-Jul	28.0
K02-15	7.65	8.3	4.2	10-Jul	21-Jul	06-Aug	28.0
K03-9	4.81	10.4	4.3	03-Jul	16-Jul	29-Jul	27.0
K06-2	4.49	11.2	4.3	07-Jul	20-Jul	02-Aug	27.0
Chemainus	3.58	13.2	3.9	04-Jul	19-Jul	07-Aug	34.8
Meeker	3.14	8.7	3.1	04-Jul	19-Jul	03-Aug	31.2
Saanich	3.37	11.7	3.5	07-Jul	21-Jul	07-Aug	32.5
Tulameen	2.93	20.1	3.8	06-Jul	19-Jul	03-Aug	29.3

Table 5. Susceptibility (S) and resistance (R) of 15 red raspberry cultivars and four selections to seven biotypes of the aphid *A. agathonica* in southwestern British Columbia.

	'Cascade Bounty' 'Latham' 'Meeker' 'Willamette'	'Newburgh'	'Algonquin' 'Chemainus' 'Malahat' 'Qualicum' 'Tulameen'	'Saanich'	'Cowichan'	'Nanoose' 'Rudi' 'Ukee'	BC 90-19-34 BC 93-16-43 BC 10-4-101 BC 10-8-102
Biotype A	S	R	R	R	R	R	R
Biotype B	S	S	R	R	R	R	R
Biotype C	S	R	S	R	R	R	R
Biotype D	S	R	S	S	R	R	R
Biotype E	S	S	S	R	S	R	R
Biotype F	S	S	S	S	S	S	R
Biotype G	S	--[z]	S	S	S	R	R

[z] Not yet tested, but expected to be susceptible based on response to 'Cowichan'

Project No:

Title: Red Raspberry Cultivar Development

Personnel: Chaim Kempler, Research Scientist, Michael Dossett, Visiting Fellow
Brian Harding 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, Chaim.Kempler@agr.gc.ca Tel: 604-796-1716 Fax: 604-796-0359 cell: 604-819-0175

Reporting Period: 2010-2013

Accomplishments:

- Began machine-harvesting replicated plots at the Clearbrook substation to evaluate machine-harvestability and yield of advanced selections.
- Tested and released BC 92-9-15 to propagators. This selection is resistant to root rot and has high-quality early season fruit suitable for fresh market or machine-harvest. While it has been slow to propagate in tissue culture, we hope that larger numbers of this selection will be available for trial in the next year or so.
- Released BC 90-19-34 and BC 93-16-43 as publically available germplasm for breeding. These two selections represent new sources of resistance to root rot and aphids, and BC 93-16-43 represents a new source of resistance to RBDV as well.
- Developed and validated a semi-hydroponic system for assessing root rot resistance in the greenhouse. This system not only allows for cycling root rot trials more quickly but also is based on visual ratings of root symptoms rather than ratings of above-ground symptoms as in traditional methods. To date more than 250 selections have been evaluated using this method.
- Identified 7 biotypes of the raspberry aphid and 3 new sources of resistance. This has led to reassessing strategies for selecting for aphid resistance in the future.
- Initiated work aimed at developing molecular markers linked to root rot resistance, aphid resistance and RBDV resistance.

Results:

- More than 20 selections were identified as having good machine harvestability and some potential for processing. Some of these have already been propagated and have been planted at Randy Honcoop's farm for further machine-harvest evaluations; others are still being propagated for testing on farms in BC and Washington.
- Strong resistance to root rot was identified in more than 100 selections. Some of these also have resistance to RBDV. Many of these represent far-from-market germplasm for use in further breeding but many represent elite lines with potential and will be evaluated further for machine-harvestability.
- Every source of aphid resistance currently represented in raspberry cultivars from the PNW has been broken by at least one of 7 aphid biotypes we have identified. More research is needed to learn how widespread and problematic some of these biotypes are, but it no longer makes sense for the program to screen all seedlings for resistance. Efforts will focus on identifying which resistance category elite selections fall into,

identifying new, unbroken sources of resistance, and combining new resistance sources so that they can be durable in the long-term.

Publications:

We anticipate additional publications to follow in the coming months as the manuscripts are currently in the process of being written.

Dossett, M. and C. Kempler. 2012. Biotypic diversity and resistance to the raspberry aphid *Amphorophora agathonica* Hottes in Pacific northwestern North America. *J. Amer. Soc. Hort. Sci.* In press.

Kempler, C., Muehlchen, A.M., and Forge, T.A. 2012. Screening for Resistance to *Phytophthora* Root Rot in Raspberries: Identifying New Sources of Resistance. *Acta Hort*. 926:59-64.

Zhang, Z.-M., Zhao, Z.-Y., Liu, H., Dubé, C., Charles, M.T., Kempler, C., and Khanizadeh, S. 2012. Horticultural characteristics and chemical composition of advanced raspberry lines from British Columbia. *J. Food. Agric. Environ.* 10:883-887.

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
Chaim Kempler	**Current:** AAFC, RIDC, WRRC, LMHIA	$321,281	April 1 2010 – March 31, 2013	49%	Red Raspberry Breeding for the Pacific Northwest
	AAFC, BCBC, LMHIA	$183,589	April 1 2010 – March 31, 2013	28%	Blueberry Breeding for the Pacific Northwest
	AAFC, WSC, FVSGA, LMHIA	$150,805	April 1 2010 – March 31, 2013	23%	Strawberry Breeding for the Pacific Northwest
Michael Dossett	**Pending:** AAFC, WWRC, RIDC, BCBC	$801,266	April 1, 2013 – March 31, 2018	50%	Red Raspberry Breeding for the Pacific Northwest
	AAFC, BCBC, WBC	$641,012	April 1, 2013 – March 31, 2018	40%	Blueberry Breeding for the Pacific Northwest
	AAFC, WSC, FVSGA, BCBC	$160,253	April 1, 2013 – March 31, 2018	10%	Evaluating Strawberry Cultivars and Germplasm for BC and Northern Washington

2013 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

Project Title: Red Raspberry Cultivar Development

PI: Michael Dossett
Organization: Agriculture and Agri-Food Canada
Title: Visiting Fellow
Phone: (604) 796-2221 ext. 1284
Email: Michael.Dossett@agr.gc.ca
Address: 6947 Hwy #7
Address 2:
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** 2013 **Terminating Year** 2015

Total Project Request: **Year 1 $12000** **Year 2 $12000** **Year 3 $12000**

Other funding sources:
This is part of a larger project to support berry breeding in British Columbia in the near term until longer-term solutions can be found after the program was cut by the federal government in 2012. While we are still awaiting details of the DIAP 2 funding program from Ottawa, we are planning for a total budget for running the program of $304,696 in 2013 increasing to approximately $320,288 in 2015. We have been told that the DIAP2 program will require 1:1 matching funds so half of the money budgeted must be put forward by industry. We expect that the program will be split as follows: 50% red raspberry, 40% blueberry, 10% strawberry. WRRC contribution would be leveraged 1:1 with federal matching funds and go towards the red raspberry portion ($76,174 industry funds needed in 2013). I have broken down the amounts requested from all funding sources on a separate page at the end of this proposal.

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 germplasm manageable plant 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 hardy genotypes that withstand low temperatures, desiccating winds and late breaking dormancy.
- 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: (400 words maximum)

The red raspberry industry is facing more challenges than ever with increased production costs and increased pressures on prices 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 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. We plan to continue this and extend it to our seedling evaluation in the future, because we believe this is the fastest way to identify selections with merit. 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 verbally committed to providing office and lab space in support of the continuation of this program, as well as limited 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 this effort 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.

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. The current expectation is that the next DIAP program will be for a period of five years, at which time alternative measures will need to be in place for the continuation of the program. 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). We expect to have basic linkage maps completed in the summer of 2013. The populations have already been screened for aphid resistance. Screening for root rot resistance will take place over the next three winters, and testing for RBDV infection will be an ongoing process.

Anticipated Benefits and Information Transfer: (100 words maximum)

Specific benefits that will result from this project include:

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

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

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

	2013	2014	2015
Salaries[1/]	$	$	$
Time-Slip	$10000	$10000	$10000
Operations (goods & services)	$2000	$2000	$2000
Travel[2/]	$	$	$
Meetings	$	$	$
Other	$	$	$
Equipment[3/]	$	$	$
Benefits[4/]	$	$	$
Total	**$12000**	**$12000**	**$12000**

The costs we are asking WRRC to support represent approximately 15% of the red raspberry portion of the industry contribution needed for the next DIAP cycle of funding. We have allocated this primarily to labor for field planting, plot maintenance, and harvest, as well as some operational cost towards contracting for machine-harvest of plots.

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 and are pending final approval. The RIDC, BCBC, and FVSGA have tentatively approved smaller amounts based on a prior assumption of 1:3 matching funds, as were available in the previous DIAP funding program. These groups have not yet met to address funding amounts and priorities now that we have been recently informed the program will require 1:1 matching funds; however each has stated that the breeding program is their #1 research priority and that other research projects will be targeted for cuts first.

Raspberries (50% Effort, $76,174 needed)**:**

BC Raspberry Industry Development Council	$64,174
Washington Red Raspberry Commission	$12,000

Blueberries (40% Effort, $60,939 needed)**:**

BC Blueberry Council	$50,939
Washington Blueberry Commission	$10,000

Strawberries (40% Effort, $15,235 needed)**:**

Fraser Valley Strawberry Growers Association	$10,235
Washington Strawberry Commission	$5,000

Government of Canada – Federal Matching Funds:	$152,348

Title: New strategies to control root-lesion nematodes

Personnel: Axel Elling, Assistant Professor (Nematology), Department of Plant Pathology, Washington State University, P.O. Box 646430, Pullman, WA 99164-6430

Reporting Period: 2012

Accomplishments:

This project depends on the availability of large quantities of pure *P. penetrans*. The life cycle of this nematode takes 4-6 weeks and its reproductive rate is relatively low, which makes it challenging to mass-produce *P. penetrans*. We propagated nematodes in the greenhouse, isolated them and manually removed contaminating plant material and other nematodes. In 2012, we produced a sufficient amount of root-lesion nematodes to isolate mRNA. We prepared the mRNA for sequencing and completed the actual high-throughput sequencing step at Washington University St. Louis. At present, we are preparing the sequencing data for further analyses.

Results:

We have produced enough root-lesion nematodes in the greenhouse to isolate the necessary amount of mRNA for sequencing. Samples were submitted to Washington University St. Louis, where they were sequenced. Preliminary analyses show that the sequencing results are of good quality. We are currently processing the sequencing data (*e.g.*, assembly of small overlapping fragments into longer regions, removal of plant sequences etc.) and will continue to analyze the data to find secretion and effector genes.

Publications/outputs:

'Host-parasite interactions and genomics of plant-parasitic nematodes', Department of Entomology, Washington State University, Seminar Series, Pullman, WA, September 6

'Variability in *Meloidogyne chitwoodi* and the use of effector genes as control targets', 64th International Symposium on Crop Protection, Ghent, Belgium, May 22

'Lessons from a plant-parasitic nematode: genomes and host-parasite relationships', Department of Biological Sciences, University of Idaho, Seminar Series, Moscow, ID, May 1

2013 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

Project Title: New strategies to control root-lesion nematodes

Proposed Duration: 3 years

PI: Axel Elling
Organization: Department of Plant Pathology, Washington State University
Title: Assistant Professor (Nematology)
Phone: 509-335-3742
Email: elling@wsu.edu
Address: P.O. Box 646430, Pullman, WA 99164-6430

Year Initiated 2011 **Current Year** 2013 **Terminating Year** 2013

Total Project Request: Year 1 $7,288 Year 2 $7,320 Year 3 $7,457

Other funding sources:
Agency Name: Washington Wheat Commission
Amt. Requested: $37,500
Notes: WSU is including this information on other resources available for the support of similar research undertaken by the faculty member proposing this research. These resources are listed to identify other support granted for this research and are not included as a commitment of cost-share by the institution.

Description:

The **objective** of this project is to identify nematode genes that allow root-lesion nematodes (*Pratylenchus* spp.) to infect raspberries and to establish themselves as parasites. Plant-parasitic nematodes have evolved highly sophisticated interactions with their hosts that are based on secretions from the nematode's salivary glands. These secretions (*i.e.*, effectors) are released into the plant during the infection process and enable the nematode to overcome plant defense responses. We will identify nematode genes that produce the relevant secretions (*i.e.*, effector genes). Specific **outcomes** of this project will be a list of root-lesion nematode genes that most likely play key roles in the infection process and that make attractive new targets for molecular control strategies. Additionally, we will gain a better understanding of how root-lesion nematodes infect plants and how the infection process can be interrupted.

Justification and Background:

The root-lesion nematode *Pratylenchus penetrans* is a widespread and economically important pest in Washington's raspberry production areas (McElroy 1992). Current nematode control strategies strongly depend on pre-planting applications of synthetic nematicides, but recent decisions by the EPA make it likely that fewer nematicides will be available going forward. Non-fumigant nematicides are always under regulatory threat because they are generally older, acutely toxic products. Alternative control strategies are very limited: rotations are not a feasible option in perennial crops, and resistant cultivars, which could be one of the most economic and sustainable control tactics, are not available. Therefore, the urgent development of new control methods is necessary to prevent significant yield losses due to *P. penetrans* infestations in the future. Current strategies to develop alternative control tactics against *P. penetrans* in raspberries are aimed at testing new synthetic nematicides and cover crops/green manure. The research proposed here will complement ongoing efforts to control root-lesion nematodes in raspberries as part of an integrated pest management program.

Plant-parasitic nematodes release secretions produced in their salivary glands into host plants during infection. These secretions degrade plant cell walls, thereby enabling nematode invasion and interfere with the normal functions of host plant physiology. Plant-parasitic nematodes depend on these secretions for their survival and their ability to establish themselves as parasites, which makes these secretions central to their infection strategy and an attractive target for new control methods. Recent studies have shown that disabling the nematode genes (effector genes) that produce these secretions can result in dramatically increased resistance of the host plant (Huang et al. 2006, Sindhu et al. 2009). This can either be achieved through biotechnology or traditional breeding. Whereas significant progress has been made in identifying and disabling effector genes in cyst and root-knot nematodes, information about similar genes in root-lesion nematodes is very limited.

We propose to exploit a weak link in the infection strategy of *P. penetrans*, namely its dependency on effector genes to develop new control strategies against root-lesion nematodes. In order to use nematode effector genes as new control targets, they need to be identified, which is the goal of this project. No similar research is conducted in Oregon or Idaho.

Relationship to WRRC Research Priorities:

This project will improve our understanding about root-lesion nematodes and can lead to the development of new control strategies. This project directly addresses two #1 WRRC priorities: *i)* understanding soil ecology and soil borne pathogens and *ii)* alternatives to control soil pathogens and nematodes.

Objectives:

1) Sequence *P. penetrans* transcriptome
2) Identify *P. penetrans* secretion genes and effector gene candidates

Procedures:

1) <u>Sequence *P. penetrans* transcriptome.</u>

We will follow a three-step process to find *P. penetrans* effector genes: *i*) sequence all *P. penetrans* genes (*i.e.*, its transcriptome), *ii*) separate genes that produce secretions from other genes and *iii*) screen for effector genes among secretion-producing genes.

We will collect large quantities of *P. penetrans* and clean the nematodes from contaminating plant material and other nematode species. Root-lesion nematodes will be stored in an ultra-low freezer at -80 ºC. Once a sufficient amount of nematode material has been obtained, we will isolate mRNA, which represents the message of genes. To create a collection of all *P. penetrans* genes, we will sequence all genes using high-throughput sequencing technologies. Once sequence data has been obtained, we will process it to remove contaminating sequences from plants and other organisms. The more active a given gene is, the more sequences we will obtain for that particular gene. We will sort all sequence data and generate a profile for all genes that will show us a range from the most to the least active nematode genes.

2) Identify *P. penetrans* secretion genes and effector gene candidates.

To separate *P. penetrans* genes that produce secretions from other genes, we will search for genes that contain a signal peptide-coding region using SignalP software (Bendtsen et al. 2004). The signal peptide region is a hallmark of genes that produce secretions and is therefore present in all effector genes. Once we have narrowed down the total gene library to those genes that produce secretions, we will screen for the most active effector genes. To this end, we will use a technique, in situ hybridization, which employs a color reaction specific to individual gene sequences in question. By using a microscope, we will be able to determine whether the produced pigment is present in *P. penetrans* salivary gland cells. This would indicate that the respective gene is active at that location and therefore a potential effector gene (de Boer et al. 1998). We will focus on those effector gene candidates that have the most sequence data and are therefore most active, which will facilitate further screening steps. Simultaneously, we will compare *P. penetrans* genes with genes in other root-lesion nematode species to find putative effectors. We anticipate that addressing objective 2 will take up the majority of this funding year.

Anticipated Benefits and Information Transfer:

The identification of *P. penetrans* effector genes is important, because once their identities are known, effector genes can be used as control targets. Blocking their functions would result in increased *P. penetrans* resistance. *The research proposed here is important and benefits Washington's raspberry growers, because it aids in developing new nematode control methods that reduce the use of costly nematicides and that provide an alternative control tactic as part of an integrated pest management program.* Results will be disseminated through presentations at grower meetings and scientific congresses, and through publications in trade magazines and scientific journals.

References:

Bendtsen, J.D., Nielsen, H., von Heijne, G. and Brunak, S. 2004. Improved prediction of signal peptides: SignalP 3.0. Journal of Molecular Biology 340: 783-795.

de Boer, J.M., Yan, Y., Smant, G., Davis, E.L. and Baum, T.J. 1998. In-situ hybridization to messenger RNA in *Heterodera glycines*. Journal of Nematology 30: 309-312.

Gao, B., Allen, R., Maier, T., Davis, E.L., Baum, T.J. and Hussey, R.S. 2003. The parasitome of the phytonematode *Heterodera glycines*. Molecular Plant-Microbe Interactions 16: 720-726.

Huang, G., Allen, R., Davis, E.L., Baum, T.J. and Hussey, R.S. 2006. Engineering broad root-knot resistance in transgenic plants by RNAi silencing of a conserved and essential root-knot nematode parasitism gene. Proceedings of the National Academy of Sciences U.S.A. 103: 14302-14306.

Huang, G., Gao, B., Maier, T., Allen, R., Davis, E.L., Baum, T.J. and Hussey, R.S. 2003. A profile of putative parasitism genes expressed in the esophageal gland cells of the root-knot nematode *Meloidogyne incognita*. Molecular Plant-Microbe Interactions 16: 376-381.

McElroy, F.D. 1992. A plant health care program for brambles in the Pacific Northwest. Journal of Nematology 24: 457-462.

Sindhu, A., Maier, T.R., Mitchum, M.G., Hussey, R.S., Davis, E.L. and Baum, T.J. 2009. Effective and specific in planta RNAi in cyst nematodes: expression interference of four parasitism genes reduces parasitic success. Journal of Experimental Botany 60: 315-324.

Budget:

	2011	**2012**	**2013**
Salaries			
Time-slip[1/]	$3,000	$3,120	$3,245
Operations (Goods & services)	$3,700	$3,600	$3,600
Travel[2/]	$300	$300	$300
Meetings			
Other			
Equipment			
Benefits[3/]	$288	$300	$312
Total	**$7,288**	**$7,320**	**$7,457**

Budget Justification:

[1/]Partial support for an undergraduate student. Depending on outcome of funding decisions about related grant proposals, monies may also be used to partially support a Ph.D. student (summer salary).

[2/]Travel from Pullman to commission and grower meetings, and to present results at WSU Small Fruits Workshop.

[3/]Benefits 9.6%.

Current & Pending Support

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:				
Elling, A.A.	Washington State Potato Commission	$31,516	7/1/12-6/30/13	5	New strategies to control root-knot and root-lesion nematodes in potato
Elling, A.A.	Idaho Potato Commission	$30,000	9/1/12-8/31/13	5	New strategies to control root-knot and root-lesion nematodes in potato
Elling, A.A., Paulitz, T., Campbell, K.	Washington Wheat Commission	$53,500	7/1/12-6/30/13	5	Development of integrated resistance against root-lesion nematodes in wheat
Brown, C., Elling, A.A.	USDA Specific Cooperative Agreement	$54,290	7/1/12-6/30/13	5	Enhancing host resistance against Columbia root-knot nematode
Elling, A.A.	Washington Red Raspberry Commission	$7,320	7/1/12-6/30/13	3	New control strategies against root-lesion nematodes
Jensen, A., Elling, A.A., Brown, C.	Washington State Department of Agriculture	$125,000	10/1/11-9/30/14	10	Filling the gaps in nematode management in potatoes
	Pending:				
Elling, A.A.	This application	$7,457	7/1/13-6/30/14	3	New control strategies against root-lesion nematodes
Elling, A.A., Paulitz, T., Campbell, K.	Washington Wheat Commission	$75,000	7/1/13-6/30/14	5	Management of nematode disease with genetic resistance
Elling, A.A.	WSU ERI	$36,546	1/1/13-12/31/13	5	Phylogeography to improve resistance breeding against Columbia root-knot nematode
Horowitz, S., Elling, A.A.	BARD	$333,426	8/1/13-7/31/16	10	Dissecting interactions between root-knot nematode effectors and lipid signaling pathways involved in plant defense

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: <u>**2012**</u>

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. 'Vintage' has been released.
'Lewis' and ORUS 1142-1 are being propagated for grower trials as floricane fruiters and ORUS 4090-1 and ORUS 4090-2 as primocane fruiters. ORUS 1040-1 did not hold up well in machine harvest trial in Lynden, WA and is being discarded. Five selections have been propagated for planting in machine harvest trial in Lynden. We have 23 floricane fruiting and 19 primocane fruiting red raspberry selections from our crosses in trial, in addition to numerous WSU and BC selections. 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 37 red raspberry crosses, over 50% of our *Rubus* crosses- not sure how that happened but don't tell the blackberry guys! ;)

Results: Thirty seven red raspberry and 12 black raspberry crosses were successfully made in spring 2012. A new seedling field was established containing red raspberry, black raspberry and blackberry seedlings. Forty three red raspberry selections were made (17 floricane, 17 primocane, 9 germplasm). The selections were mostly made as potential cultivars however several are germplasm selections with a wild Midwest *R. idaeus* parent in their background. 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. We hope this material will be useful to our program as well as to Pat Moore's and Chaim Kempler's. Table RY1 lists the genotypes that were harvested in 2012 or will be harvested in 2013. Presented in Tables RY2-RY5 are the results from 2012. ORUS 4090-1 and ORUS 4090-2 are being propagated for trial in addition to ORUS 1142-1 and 'Lewis'. 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.

While not directly related to red raspberry at first glance, our efforts in black raspberry have identified verticillium wilt resistance and aphid resistance (that should translate into virus resistance for the aphid transmitted viruses). While verticillium has not been a problem in the past there was some concern raised in 2012 that there may be more problems with verticillium than we were aware. 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: Patent for 'Vintage' was filed. Until a new cultivar is released and the notice published in a scientific journal, results from our trial are mostly presented informally in Commission reports and oral presentations.

Appendices

Table RY1. Red raspberry genotypes in the ground for evaluation in 2012 and/or 2013.

Floricane Fruiters			*Primocane Fruiters*	
BC 3-14-12	WSU 1499	WSU 1960	NY 02-57	Amity
BC 96-22R-55	WSU 1507	WSU 1961	NY 05-44	Anne
ORUS 1142-1	WSU 1511		ORUS 2786-2	Autumn Bliss
ORUS 3229-1	WSU 1530	Canby	ORUS 3983-3	Autumn Britten
ORUS 3234-1	WSU 1539	Cascade Bounty	ORUS 4086-3	Caroline
ORUS 3533-2	WSU 1568	Cascade Dawn	ORUS 4090-1	Chinook
ORUS 3539-1	WSU 1605	Cascade Delight	ORUS 4090-2	Crimson Giant
ORUS 3702-2	WSU 1629	Cascade Gold	ORUS 4097-1	Crimson Night
ORUS 3702-3	WSU 1660	Chemainus	ORUS 4097-5	Double Gold
ORUS 3702-4	WSU 1713	Chilliwack	ORUS 4099-1	Fallgold
ORUS 3705-1	WSU 1747	Coho	ORUS 4287-1	Goldie (Graton Gold)
ORUS 3705-2	WSU 1750	Cowichan	ORUS 4280-2	Heritage
ORUS 3707-1	WSU 1792	Lewis	ORUS 4280-3	Joan Irene
ORUS 3707-2	WSU 1794	Malahat	ORUS 4285-1	Josephine
ORUS 3711-1	WSU 1848B	Meeker	ORUS 4289-1	Nantahala
ORUS 3711-2	WSU 1912	Nanoose	ORUS 4289-3	Oregon 1030.002
ORUS 3713-1	WSU 1948	Octavia	ORUS 4289-4	Summit
ORUS 3718-1	WSU 1950	Rudi	ORUS 4289-5	Vintage
ORUS 3718-2	WSU 1951	Saanich	ORUS 4291-1	
ORUS 3722-1	WSU 1952	Tulameen	ORUS 4388-1	
ORUS 3722-2	WSU 1953	Ukee	ORUS 4389-1	
ORUS 3767-1	WSU 1954	Wakefield		
ORUS 3767-2	WSU 1955	Willamette		
ORUS 3767-3	WSU 1956			
ORUS 3959-3	WSU 1957			
ORUS 4097-4	WSU 1958			

Table RY2. Mean yield and berry size in 2011-12 for floricane fruiting raspberry genotypes at OSU-NWREC planted in 2009.

Error! Not a valid link.		Berry size (g)		Yield (kg·plt^{-1})			Yield (tons·a^{-1})
Genotype	2011-12	2011	2012	2011-12	2011	2012	2011-12
Observation							
Saanich	3.4	2.71	2.28	2.50	3.91	3.28	3.60
Lewis	4.3	1.95	2.04	1.99	2.80	2.93	2.87
Meeker	**3.2**	**1.76**	**2.17**	**1.97**	**2.54**	**3.13**	**2.83**
WSU 1629	5.1	2.24	1.67	1.95	3.22	2.41	2.81
WSU 1956	3.3	1.77	2.03	1.90	2.55	2.92	2.73
Rudi	3.5	1.86	1.88	1.87	2.67	2.71	2.69
WSU 1605	4.7	2.10	1.15	1.62	3.02	1.65	2.33
ORUS 1142-1	3.7	1.26	1.80	1.53	1.82	2.59	2.20
WSU 1568	4.0	1.95	1.06	1.50	2.80	1.53	2.16
ORUS 3539-1[z]	3.2	1.09	1.77	1.43	1.57	2.55	2.06
WSU 1957	3.2	1.54	1.18	1.36	2.22	1.70	1.96
WSU 1950	2.8	1.21	1.30	1.25	1.74	1.87	1.80
WSU 1960	4.2	1.30	1.02	1.16	1.87	1.47	1.67
Ukee	3.7	1.13	0.93	1.03	1.63	1.34	1.49
WSU 1958	2.9	0.59	1.20	0.89	0.84	1.72	1.28
Cascade Gold	7.3[y]	.	1.93	.	.	2.78	.

[z] ¼ *Rubus parvifolius*, ¾ cultivated red raspberry.

Table RY3. Mean yield and berry size in 2012 for floricane fruiting red raspberry genotypes in replicated and observation trials at OSU-NWREC planted in 2010.

Genotype	Berry size (g)[z]	Yield (kg·plt^{-1})	Yield (tons·a^{-1})
Replicated			
Meeker	**3.7 c**	**3.94 a**	**5.67 a**
WSU 1507	4.8 b	3.92 a	5.65 a
ORUS 3702-4	5.8 a	1.62 b	2.33 b
Observation			
ORUS 3707-1	4.3	3.85	5.54
ORUS 3959-1	4.0	3.75	5.39
ORUS 3705-2	5.3	3.73	5.37
ORUS 3959-2	4.6	3.14	4.52
ORUS 3722-1	5.6	3.04	4.37
ORUS 3767-1	3.7	2.69	3.87
ORUS 3713-1	4.3	2.69	3.87
ORUS 3959-3	5.4	2.55	3.66
ORUS 3958-1	4.6	2.54	3.66
ORUS 3767-3	3.7	2.42	3.49
ORUS 3961-1	5.3	2.38	3.43
ORUS 3767-2	3.9	2.03	2.91
ORUS 3771-1	4.4	2.00	2.87
ORUS 3722-2	5.8	1.34	1.93
ORUS 3696-1	3.1	1.11	1.60
ORUS 3705-1	6.1	1.03	1.48

Mean separation within columns by Duncan=s $p \leq 0.05$.

Table RY4. Mean yield and berry size in 2010-2012 for primocane fruiting raspberry genotypes at OSU-NWREC planted in 2009.

	Berry size (g) 2009-11	Yield (kg·plt^{-1}) 2010-12	Yield (tons·a^{-1}) 2010-12
Replicated			
2010	2.1 b	0.88 b	1.26 b
2011	2.5 a	1.49 a	2.14 a
2012	2.7 a	1.90 a	2.73 a
ORUS 2786-2	2.8 a	1.27 a	1.82 a
Heritage	1.8 b	1.10 a	1.58 a
Nonreplicated			
Autumn Britten	3.0	1.58	2.28
Caroline	2.3	1.40	2.01
Joan Irene	2.5	0.65	0.93
Nantahala	2.5	0.37	0.53

Mean separation within columns by Duncan=s $p \leq 0.05$.

Table RY5. Mean yield and berry size in 2011-12 for primocane fruiting red and purple raspberry genotypes at OSU-NWREC planted in 2010.

	Berry size (g)	Yield (kg·plt^{-1})			Yield (tons·a^{-1})		
	2011-12	2011	2012	2011-12	2011	2012	2011-12
Replicated							
2011	3.4 a			1.09 a			3.58 a
2012	3.4 a			2.49 b			1.57 b
ORUS 4090-1	3.6 a	1.74 a	2.86 a	2.30 a	2.50 a	4.12 a	3.31 a
Heritage	**2.9 b**	**0.58 c**	**2.59 a**	**1.58 b**	**0.83 c**	**3.73 a**	**2.28 b**
ORUS 4090-2	3.7 a	0.96 b	2.00 b	1.48 b	1.38 b	2.88 b	2.13 b
Observation							
ORUS 4097-2	3.3	1.45	2.53	1.99	2.09	3.65	2.87
ORUS 4097-1	4.3	1.03	2.55	1.79	1.48	3.68	2.58
ORUS 4086-1	4.1	1.38	0.22	0.80	1.98	0.32	1.15
ORUS 3736-1 (Purple)	6.4	0.74	0.37	0.56	1.06	0.53	0.80

Mean separation within columns by Duncan=s p≤0.05.

Table RY6. Mean yield and berry size in 2012 for primocane fruiting red raspberry genotypes at OSU-NWREC planted in 2011.

Genotype	Berry size (g)	Yield (kg·plt^{-1})	Yield (tons·a^{-1})
Replicated			
ORUS 4287-1	3.7 ab	1.73 a	2.49 a
ORUS 4090-2	3.5 b	1.64 a	2.36 a
ORUS 4086-3	3.9 ab	1.58 a	2.28 a
ORUS 4097-1	4.0 a	1.47 a	2.12 a
ORUS 4097-5	2.9 c	1.42 a	2.05 a
Non replicated			
ORUS 4097-3	4.1	3.59	5.17
ORUS 4280-1	3.6	1.67	2.40
ORUS 4097-4	3.7	1.00	1.44
ORUS 4098-1	2.3	0.99	1.43
ORUS 4099-2	4.6	0.97	1.40
ORUS 4289-2	2.7	0.96	1.37
ORUS 4289-1	2.4	0.94	1.35
Oregon 1030	2.8	0.78	1.12

Mean separation within columns by Duncan=s p≤0.05.

Table RY7. Ripening season for floricane fruiting red raspberry genotypes at OSU-NWREC. Planted in 2009-10 and harvested 2011-12.

Genotype	Year planted	Harvest season 5%	50%	95%	No. years in mean	Rep/ Obsv.
Cascade Gold	2009	19-Jun	26-Jun	26-Jun	1	Obsv
ORUS 3771-1	2010	19-Jun	26-Jun	3-Jul	1	Obsv
ORUS 3767-2	2010	19-Jun	3-Jul	3-Jul	1	Obsv
ORUS 3767-3	2010	19-Jun	3-Jul	17-Jul	1	Obsv
ORUS 3707-1	2010	26-Jun	3-Jul	17-Jul	1	Obsv
ORUS 3722-1	2010	26-Jun	3-Jul	17-Jul	1	Obsv
ORUS 3959-2	2010	26-Jun	3-Jul	17-Jul	1	Obsv
ORUS 1142-1	2009	27-Jun	4-Jul	18-Jul	2	Obsv
WSU 1958	2009	27-Jun	4-Jul	18-Jul	2	Obsv
Rudi	2009	27-Jun	7-Jul	18-Jul	2	Obsv
WSU 1957	2009	30-Jun	7-Jul	21-Jul	2	Obsv
ORUS 3767-1	2010	26-Jun	10-Jul	24-Jul	1	Obsv
WSU 1507	2010	26-Jun	10-Jul	31-Jul	1	Rep
ORUS 3705-2	2010	3-Jul	10-Jul	7-Aug	1	Obsv
WSU 1605	2009	30-Jun	11-Jul	25-Jul	2	Obsv
WSU 1960	2009	30-Jun	11-Jul	25-Jul	2	Obsv
WSU 1568	2009	4-Jul	11-Jul	21-Jul	2	Obsv
Meeker	2009	4-Jul	11-Jul	25-Jul	2	Obsv
Ukee	2009	4-Jul	11-Jul	25-Jul	2	Obsv
Saanich	2009	4-Jul	14-Jul	28-Jul	2	Obsv
WSU 1950	2009	7-Jul	14-Jul	25-Jul	2	Obsv
ORUS 3713-1	2010	26-Jun	17-Jul	31-Jul	1	Obsv
ORUS 3958-1	2010	26-Jun	17-Jul	31-Jul	1	Obsv
ORUS 3961-1	2010	26-Jun	17-Jul	31-Jul	1	Obsv
ORUS 3702-4	2010	26-Jun	17-Jul	31-Jul	1	Rep
ORUS 3722-2	2010	3-Jul	17-Jul	17-Jul	1	Obsv
ORUS 3959-1	2010	3-Jul	17-Jul	31-Jul	1	Obsv
Meeker	2010	3-Jul	17-Jul	31-Jul	1	Rep
ORUS 3959-3	2010	3-Jul	17-Jul	7-Aug	1	Obsv
WSU 1956	2009	4-Jul	18-Jul	4-Aug	2	Obsv
WSU 1530	2009	5-Jul	19-Jul	26-Jul	1	Obsv
WSU 1961	2009	12-Jul	19-Jul	2-Aug	1	Obsv
Lewis	2009	11-Jul	25-Jul	8-Aug	2	Obsv
WSU 1629	2009	14-Jul	25-Jul	11-Aug	2	Obsv
ORUS 3539-1	2009	18-Jul	25-Jul	8-Aug	2	Obsv

Table RY8. Ripening season for primocane fruiting red raspberry genotypes at OSU-NWREC. Planted in 2009-11 and harvested 2010-12.

Genotype	Year planted	Harvest season 5%	50%	95%	No. years in mean	Rep/ Obsv.
ORUS 3736-2	2010	11-Aug	15-Aug	1-Sep	2	Obsv
ORUS 4099-2	2011	7-Aug	21-Aug	21-Aug	1	Obsv
ORUS 4097-4	2011	14-Aug	21-Aug	28-Aug	1	Obsv
ORUS 4097-4	2011	14-Aug	21-Aug	28-Aug	1	Obsv
ORUS 2786-2	2009	6-Aug	27-Aug	24-Sep	3	Rep
Autumn Britten	**2009**	**11-Aug**	**27-Aug**	**8-Sep**	**3**	**Obsv**
Joan Irene	2009	20-Aug	27-Aug	8-Sep	3	Obsv
ORUS 4280-1	2011	14-Aug	28-Aug	11-Sep	1	Obsv
ORUS 4289-2	2011	14-Aug	28-Aug	18-Sep	1	Obsv
ORUS 4090-2	2011	14-Aug	28-Aug	25-Sep	1	Rep
ORUS 4287-1	2011	14-Aug	28-Aug	25-Sep	1	Rep
Oregon 1030.002	2011	21-Aug	28-Aug	28-Aug	1	Obsv
ORUS 4086-1	2010	15-Aug	29-Aug	8-Sep	2	Obsv
ORUS 4086-2	2011	14-Aug	4-Sep	2-Oct	1	Obsv
ORUS 4289-1	2011	21-Aug	4-Sep	25-Sep	1	Obsv
ORUS 4097-3	2011	21-Aug	4-Sep	2-Oct	1	Obsv
ORUS 4098-1	2011	21-Aug	4-Sep	2-Oct	1	Obsv
ORUS 4086-3	2011	21-Aug	4-Sep	2-Oct	1	Rep
Heritage09	**2009**	**22-Aug**	**5-Sep**	**22-Sep**	**3**	**Rep**
Caroline	2009	25-Aug	5-Sep	19-Sep	3	Obsv
ORUS 4090-2	2010	18-Aug	8-Sep	26-Sep	2	Rep
ORUS 4090-1	2010	18-Aug	8-Sep	29-Sep	2	Rep
ORUS 4097-2	2010	22-Aug	8-Sep	29-Sep	2	Obsv
Heritage10	**2010**	**25-Aug**	**8-Sep**	**29-Sep**	**2**	**Rep**
ORUS 4097-1	2011	21-Aug	11-Sep	2-Oct	1	Rep
ORUS 4097-5	2011	21-Aug	11-Sep	9-Oct	1	Rep
Nantahala	2009	8-Sep	15-Sep	24-Sep	3	Obsv
ORUS 4097-1	2010	29-Aug	15-Sep	6-Oct	2	Obsv

Project Title: Cooperative raspberry cultivar development program

PI: Chad Finn,
USDA-ARS, HCRL
Research Geneticist
541-738-4037
Chad.finn@ars.usda.gov
3420 NW Orchard Ave.
Corvallis, OR 97330

Cooperators: Pat Moore, WSU
Chaim Kempler Agriculture and Agri-Foods Canada

Year Initiated __2012___ **Current Year** 2013-2014__ **Terminating Year** _Continuing__

Total **Project Request:** Ongoing. Year 1: $6,500

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.

I have received significant funding from the USDA-ARS, Northwest Center for Small Fruit Research and the USDA-ARS Plant Exploration Office towards our black raspberry research. We will receive matching funds from the North American Raspberry and Blackberry Association ($3000) and from WRRC ($1,000) for matching funding on a black raspberry SCRI grant. While a different crop, red and black raspberry are closely related and their genetics have a lot in common and we hope that much of what we learn about aphid resistance and verticillium tolerance in black raspberry will carry over to red raspberry.

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' 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 (#3 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:

- 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 (#3 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 (3 replications of 3 plants each plus a 3 plant observation plot). Selections that we are less sure of are generally planted in smaller observation trials (single, 3 plant plots). 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 four 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)	$3,000
Operations (goods & services)	500
Travel[1]	1,000
Other: “Land use charge” ($3,500/acre)	2,000
Total	**$6,500**

[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	7/2012-6/2013	1	Funds towards industry matching on SCRI grant "Developing the Genomic Infrastructure for Breeding Improved Black Raspberries"
Finn, C.E. and J. Lee	Northwest Center for Small Fruit Research	$32,500	7/2012-6/2014	2	Extending RosBREED in the Pacific Northwest for strawberry processing traits
Finn, C.E.	Oregon Blueberry Commission	10,000	7/2012-6/2013	2	Blueberry breeding-seedlings
Strik, BC, and Finn, C.E.	Oregon Blueberry Commission	17,000	7/2012-6/2013	2	Cooperative Breeding Program- Blueberries
Finn, C.E.	Oregon Raspberry and Blackberry Commission	$1,000	7/2012-6/2013	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	$23,000	7/2012-6/2013	2	Production System/Physiology Research and Cooperative Breeding Program- Raspberries and Blackberries
Strik, B.C. and C.E. Finn	Oregon Strawberry Commission	$12,000	7/2012-6/2013	2	Cooperative Breeding Program - Strawberries
Iezzoni, A. and 29 team members	USDA- SCRI (2009-51181-05808)	$7,831,469	9/2009-8/2013	5	RosBREED: Enabling marker-assisted breeding in Rosaceae
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,	USDA Specialty Crop Research Initiative	$1,590,717	10/1/2011-9/30/2015	10	Developing the Genomic Infrastructure for Breeding Improved Black Raspberries

F. Fernández Fernández, S.J. Yun.					
Tzanetakis, I.E., and 11 team members.	USDA Specialty Crop Research Initiative	1,463,234	9/2009-8/2013	2	Management of virus complexes in *Rubus*.
Daniels, C.H., P.P. Moore, J.D. Swanson, C. Ross, C. Weber, G. Fernandez, R. Ming, C.E. Finn, R.R. Martin, I. Zasada, J. Udall.	USDA. SCRI Planning Grant	$49,506	10/1/2011-9/30/2012	1	Roadmap Development for U.S. Raspberry Producers: Forging Links Between New Tools for Breeding Programs and Crop Markets.
Finn, C.E.	Washington Blueberry Commission	8,400	7/2012-6/2013	2	Blueberry breeding-Cultivar and Selection evaluation
Finn, C.E.	Washington Blueberry Commission	13,068	7/2012-6/2013	2	Blueberry breeding-seedlings
Finn, C.E.	Washington Red Raspberry Commission	$4,000	7/2012-6/2013	2	Cooperative raspberry cultivar development program.
Finn, C.E.	Washington Red Raspberry Commission	$1,000	7/2012-6/2013	1	Funds towards industry matching on SCRI grant "Developing the Genomic Infrastructure for Breeding Improved Black Raspberries"
Finn, C.E.	Washington Strawberry Commission	$3,220	7/2012-6/2013	2	USDA-ARS Cooperative Strawberry Breeding Program
Name(List PI #1 first)					
Pending:					
Finn, C.E.	Washington Red Raspberry Commission	$6,500	7/2013-6/2014	2	Cooperative raspberry cultivar development program.
Finn, C.E.	Washington Red Raspberry Commission	$1,000	7/2013-6/2014	1	Funds towards industry matching on SCRI grant "Developing the Genomic Infrastructure for Breeding Improved Black Raspberries"

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
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 in Oregon, Washington, North Carolina, and New York

Reporting Period: 2012

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.

Results:
We are on track. Research plots have been established and lab work begun.

Publications:
Bassil, N.V., B. Gilmore, K. Hummer, M.Dossett, T. Mockler, S. Filichkin, M. Peterson, C.E. Finn, J. Lee, G. Fernandez, P. Perkins-Veazie, C. Weber R. Agunga, E. Rhodes, J.C. Scheerens, K. Lewers, J. Graham, F. Fernández-Fernández, and S.J. Yun. 201X. Genetic and genomic resources in black raspberry Acta Hort. Submitted (5/30/2102).

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. (Abstract)

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
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 2012 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 for support of this project.

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

Year Initiated __2011_______ Current Year 2012_____ Terminating Year _2015__

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

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.

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

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**

2013 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

Project Title: Red Raspberry trellising demonstration plot for development of automation technologies

PI: Manoj Karkee
Organization: WSU-CPAAS
Title: Assistant Professor
Phone: 509-786-9208
Email:manoj.karkee@wsu.edu
Address: 24106 N. Bunn Rd.
Address 2:
City/State/Zip: Prosser, WA 99350

Co-PI: Julie Tarara
Organization: USDA-ARS
Title: Research Horticulturist
Phone: 509-786-9392
Email: julie.tarara@ars.usda.gov
Address: 24106 N. Bunn Rd.
Address 2:
City/State/Zip: Prosser, WA 99350

Cooperators: Qin Zhang, WSU-CPAAS Tom Walters, WSU/USDA

Year Initiated <u>2013</u> Current Year <u>2013</u> Terminating Year <u>2015</u>

Total Project Request: Year 1 $11,451 Year 2 $9,698 Year 3 $2,098

Other funding sources: None (will apply to SCRI Jan 2014)

Description:
This project will establish and administer sites in Mt. Vernon and Prosser where researchers, growers and others can present, discuss, implement, and evaluate practices for raspberry training that will facilitate mechanization of at least part of the labor-intensive pruning and tying procedure for red raspberries. The Prosser site will serve for demonstration and prototype testing by the engineering group at WSU-CPAAS (Karkee, Zhang). At Mount Vernon, we propose workshops during the 2013 and 2014 pruning/tying seasons to discuss and test training options. Machine harvestability will be evaluated during harvest; the group will reconvene in December 2013 and 2014 to evaluate systems' potential for mechanized cane removal and tying. A set of existing plots at Mt. Vernon is currently planted in a randomized complete block design to four common raspberry varieties: 'Meeker', 'Chemainus', 'Saanich' and 'Cascade Bounty'. These plots will accommodate up to six potential training systems per cultivar. An additional set of plots at Mount Vernon contains randomized plots of 'Meeker' and 'Cascade Bounty', and can accommodate up to six additional training systems per cultivar. Results from 2013 will support an SCRI proposal on mechanization of berry systems, to be submitted in January 2014.

Justification and Background:
The issue we plan to address: Pruning and tying are expensive, labor-intensive processes, accounting for over $500 per acre, or 32% of the annual direct costs of growing red raspberry in Washington (MacConnell and Kangiser, 2007). Karkee and Zhang established through a series of stakeholder meetings and interviews (2012) that red raspberry cane removal and tying are among

the operations amenable to and desirable for mechanization. We will identify and evaluate grower-generated proposals for potential training systems in common Washington red raspberry varieties. The main evaluation plot will be at WSU-Mount Vernon NWREC. We will invite growers, engineers, and others to bring and try out ideas in this field; we will trellis sample rows accordingly. We expect much of the effort to be centered around economical and efficient ways of separating floricanes and primocanes, speeding the process of removing floricanes during pruning and tying. Ideas developed for other systems, such as the rotating cross arm trellis for blackberry (Takeda and Phillips, 2011), will also be considered.

Why we plan to address it: Successful mechanization of all or part of the pruning /tying operation would reduce labor costs and reduce reliance on labor in the winter when it is the most difficult to find. Karkee and Zhang determined that raspberry training/tying would be among the simpler operations to mechanize, with a long term goal of mechanizing pruning.

How this project relates to other projects in Idaho and Oregon: The WSU-CPAAS group intends to submit a proposal to USDA NIFA's SCRI on mechanization of canopy management, with applications to red raspberry and other berry crops. By developing preliminary data on raspberry and developing connections between raspberry growers and CPAAS engineers, this project will ensure that raspberry growers have the opportunity to provide input into that proposal.

Relationship to WRRC Research Priority(s): This project directly addresses the #3 priority “Labor saving cultural practices including mechanical pruning and tying techniques”. By evaluating current major varieties with a range of plant architectures, it also contributes to the commission’s #1 priority of cultivar development.

Objectives to be accomplished in 2013:

1. By using field workshops with growers for conceptual direction, implement these concepts for trellising/training on four common raspberry varieties.
2. Evaluate machine harvestability and mechanically aided pruning/trellising of plants grown with these trellising/training systems.
3. Develop robust preliminary data for a larger SCRI proposal to be submitted in January 2014.

Procedures:
This project will begin in January 2013 and continue through December of 2015. Activities include:

Trellising/training workshops: We will hold one or two grower workshops (as participation dictates) at WSU-Mount Vernon NWREC in January, 2013 with agricultural engineers (Karkee, Zhang), horticulturists (Tarara, Walters, Strik, Bryla, Finn), and raspberry growers. Participants will be encouraged to suggest concepts for training systems that the group will demonstrate on site. A block with randomized 30 ft plots of four cultivars is available for demonstrating and implementing the consensus on feasible systems for facilitating mechanically aided pruning. Up to six systems will be evaluated in each of four cultivars: ‘Meeker’, ‘Cascade Bounty’, ‘Saanich’ and ‘Chemainus’; up to six additional systems can be evaluated in a separate block of ‘Meeker’ and ‘Cascade Bounty’. Similar workshop(s) will be held in January 2014 to review current season’s results and improve upon the trellising ideas for the following year. It should be noted that the planned SCRI proposal will be submitted in January 2014.

Mechanical harvest: Trellised plots will be harvested by machine two times per week during harvest season, typically July 4-July 28. Fruit weight will be recorded, and observations of plant damage, harvester losses, and other factors will be made as warranted.

Pruning: Plots will be pruned in December 2013 and 2014. Variables measured will be time to remove old canes, pruning accuracy (number of floricanes remaining; number of primocanes removed), time to tie or otherwise attach new canes to the trellis, and other data appropriate to evaluating their potential for mechanically-aided pruning and/or trellising. The engineering group will rate the training systems for ease of potential mechanization.

Establishment of demonstration plot at Prosser: Four or five cultivars matching those at Mt. Vernon will be planted and raised in a small plot (equivalent 300' of row) for the familiarization of the engineering team with the cultivars' growth habits and for testing of mechanized concepts.

Anticipated Benefits and Information Transfer:

This project will develop training systems with the best potential to facilitate development of mechanized approaches to both training and pruning, which will ultimately reduce the estimated $500/A 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:

MacConnell, C. and M. Kangiser, 2007. Washington machine harvested red raspberry cost of production study for field re-establishment. Whatcom County Extension.

Takeda, F. and J. Phillips. 2011. Horizontal Cane Orientation and Rowcover Application Improve Winter Survival and Yield of Trailing,'Siskiyou,' Blackberry. HortTechnology. 21:170-175.

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

	2013	2014	2015
Salaries	$	$	$
Time-Slip[1/]	$4000	$2500	$500
Operations (goods & services)	$500	$500	$500
Travel[2/]	$5600	$5600	$
Meetings[3/]	$200	$200	$200
Other[4/]	$475	$475	$475
Equipment	$	$	$
Benefits[5/]	$676	$423	$423
Total	**$11451**	**$9698**	**$2098**

Budget Justification

[1/] $2000 in 2013 and 2014 at Mount Vernon to implement selected pruning/tying ideas Feb, to collect harvest data July, and to prune and train plots December of each year. $1500 to establish plots at Prosser in 2013, and $500 to maintain Prosser plots in 2013, 2014 and 2015

[2/] This project requires travel of faculty to the grower workshops for the proposed work to occur. $5600 in 2013 and in 2014 for Tarara, Karkee, Zhang and one additional scientist to make 2 trips to Mount Vernon. Because of uncertain mountain pass conditions, Pasco to SeaTac flights are necessary.

[3/] $200 annually for supplies and refreshments for pruning/tying workshops in Mount Vernon

[4/] Land use fee at WSU-Prosser IAREC

[5/] Timeslip benefits 16.9%

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					
Grieshop (PD); Brunner; Agnell; Styles; Landers; Wise; Perry; Nye; Zhang; Karkee; Gut; J. Miller; Wholon; Flore; Lang; Whiting; Hanrahan; Schmidt; Cox; Sundin; Xiao; Demarree; S. Miller; Shumway; Schwallier; Brown; Rothwell; Lizotte; Hoheisel	USDA-NIFA-SCRI	$2,472,895	09/11 to 09/13	20%	Development and optimization of solid-set canopy delivery systems for resource-efficient, ecologically sustainable apple and cherry production
Karkee (PI); Zhang; Lewis	WTFRC	$67,506	06/11 to 05/13	5%	3D machine vision for improved apple crop load estimation
Hashimoto (PD); Cooper; Eggeman; Jakeway; Karkee; Khanal; Murray; Murthy; Ogoshi; Regentin; Vaughn; Yanagida; Zhang	USDA Biomass Research and Development Initiative	$6,000,000	04/12 to 03/16	15%	Conversion of High-Yield Tropical Biomass into Sustainable Biofuels
Karkee (PI); Zhang; Lewis; De Kleine	WTFRC	$53,395	06/12 to 05/13	5%	Design and development of apple harvesting techniques
Whiting, M (PD); Almenar, E.; Dhingra, A.; Grant, J.; Harte, J.; Karkee, M. Long, L. Oraguzie, N.; Ross, C. Seavert, C. F.; Zhang, Q.;	USDA-NIFA-SCRI	$5,000,000	10/09 to 09/13	10%	A total systems approach to developing a sustainable, stem-free sweet cherry production, processing, and marketing system.
Alva (PI); Karkee; Zhang	USDA-ARS-Cooperative Research	$15,000	10/2011-09/2013	2%	Nutrient and Water Stress Sensing for Potatoes.
PENDING					
Karkee (PI), Tarara, Walters, Zhang	WA Red Raspberry Commission	$23,012	1/13 to 12/15	2%	*This Proposal:* Red raspberry trellising demonstration plot for development of automation technologies.
He (PI), Zhang, Karkee, Zhao	WA Tree Fruit Research Commission	$103,680	11/2012 to 10/2014	2%	Hand picking motion study based conceptual apple harvest end-effector

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
	Current:				
Tarara	NCSFR (No project #; Internal to ARS)	$35,000	Oct. 1, 2012 to Sept. 30, 2013	5%	Is timing the key to good fruit phenolics?
Hirst	NIFA-SCRI (not yet assigned)	$3,027,747	Sept. 1, 2012 to Aug. 31, 2016	20%	Automation of dormant pruning of specialty crops
Skinkis	OWB	$32,987	April 2012 to April 2013	5%	Understanding vine balance and cropping levels in Oregon vineyards
	Pending: none				

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: 2012-13

Accomplishments: The herbicide trial was conducted at WSU NWREC. Two other raspberry trials were conducted during 2012: an IR-4 performance trial for Dual Magnum (s-metolachlor), Prowl H2O (pendimethalin), and Facet (quinclorac), and a polytunnel raspberry herbicide trial in Invergowrie, Scotland. Data for the herbicide trial are reported here; data from all the trials will be presented during the red raspberry portion of the Northwestern Washington Small Fruit Conference in Lynden in December, 2012.

Materials and Methods:

The trial was conducted on established 'Meeker' at WSU NWREC. Callisto (mesotrione) was applied preemergence (PRE) to primocanes alone at two rates and in combination with Sinbar (terbacil), simazine, Reflex (fomesafen), or Dual Magnum on March 24, 2012. Stinger (clopyralid) was applied postemergence (POST) June 3, 2012. Plots were caneburned with Aim (carfentrazone) April 12 (whole bed). Weed control and crop injury were evaluated May 2, and June 13, 19, and 29. Berries were machine harvested eight times July 9 through August 7. The design was a randomized complete block with four replicates.

Results:

There was no visible primocane injury resulting from any Callisto application, either alone or in combination (Table 1). Stinger application in early June caused leaf cupping and other epinastic growth in foliage, which persisted through the end of June. Weed control was initially excellent, ranging from 90 to 98% in early May; control from all treated plots exceeded 80% by the end of June. The primary weed in the plots was fringed willow-herb (*Epilobium ciliatum*), with field horsetail (*Equisetum arvense*) and dandelion (*Taraxacum officinale*) also present in many of the plots. Total berry yield was similar for all treatments, ranging from 6224 to 7280 lb/acre.

These results indicate that the herbicides used in this trial were safe for established red raspberry. Stinger applied POST caused slight damage to primocane foliage, but did not negatively affect berry yield.

Table 1. Primocane injury and weed control following application of several herbicides in red raspberry (2012).

Treatment[a]	Rate	Primocane injury[b]				Weed control[b]			
		5/2	6/13	6/19	6/29	5/2	6/13	6/19	6/29
	product/a	%	%	%	%	%	%	%	%
Callisto + Sinbar	3 fl.oz + 1.5 lb	0	0 c	0 c	0 c	98 a	95	95 a	95 a
Callisto + simazine	3 fl.oz + 3 qt	0	0 c	0 c	0 c	96 ab	94	95 a	95 a
Callisto + Reflex	3 fl.oz + 2 pt	0	0 c	0 c	0 c	95 ab	93	93 ab	95 a
Callisto + Dual Magnum	3 fl.oz + 2 pt	0	0 c	0 c	0 c	95 ab	90	95 a	95 a
Stinger	5.3 fl.oz	---	15 b	5 b	5 b	---	96	93 ab	95 a
Stinger	10.7 fl.oz	---	25 a	8 a	10 a	---	91	91 ab	95 a
Callisto	3 fl.oz	0	0 c	0 c	0 c	93 ab	86	90 ab	84 b
Callisto	6 fl.oz	0	0 c	0 c	0 c	90 b	79	86 bc	94 a

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

[a]Callisto and Callisto tank mixtures were applied March 25 (PRE), Stinger was applied June 3 (POST), 2012.

[b]Primocane injury and weed control on May 2 were prior to Stinger application.

Table 2. Raspberry yield following application of several herbicides (2012).

Treatment[a]	Rate	Total berry harvest[b]
	product/a	lbs/a
Callisto + Sinbar	3 fl.oz + 1.5 lb	7280
Callisto + simazine	3 fl.oz + 3 qt	7262
Callisto + Reflex	3 fl.oz + 2 pt	7351
Callisto + Dual Magnum	3 fl.oz + 2 pt	6459
Stinger	5.3 fl.oz	6894
Stinger	10.7 fl.oz	6964
Callisto	3 fl.oz	6381
Callisto	6 fl.oz	6224
Non-treated	---	6720

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

[a]Callisto and Callisto tank mixtures were applied March 25 (PRE), Stinger was applied June 3 (POST), 2012.

[b]Berries harvested eight times by machine (July 9 through August 7, 2012).

2013 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

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

PI: Tim Miller
Organization: Washington State University
Title: Extension Weed Scientist
Phone: (360) 848-6138
Email: twmiller@wsu.edu
Address: 16650 State Route 536
City/State/Zip: Mount Vernon, WA 98273

Cooperators: The anticipated cooperator is Sakuma Brothers Farm, Bow, WA

Year Initiated __2013__ **Current Year** __2013__ **Terminating Year** __2013__

Total Project Request: **Year 1 $4,595** **Year 2 $0** **Year 3 $0**

Other funding sources: Herbicides are generally provided by the manufacturer.

Description: Weeds continue to be problematic in red raspberry production. In order to better manage them, it would be beneficial to gain registrations for new herbicides. A thorough testing of new herbicides alone and in combination with existing products is necessary to achieve both improved weed control while maintaining crop safety. Products of interest are Stinger (clopyralid), Facet (quinclorac), Treevix (saflufenacil), 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:

Perennial weed species generally become more important the longer raspberry blocks are left in production. These weeds often will outlive the raspberry crop and are also difficult to control in the break crop between raspberry plantings, so they generally remain a problem in the subsequent raspberry planting. Yet another difficulty with perennial weeds in raspberry is the physical interference to berry drop using machine harvesters, which may result in berry loss. They also impact harvest of hand-picked fruit, reducing the efficiency of hand harvest by making berries harder to find and pick.

Perennial weeds 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, ballooning herbicide and labor costs and becoming a major factor in reducing the longevity of raspberry plantings.

Trials with Stinger in healthy raspberries over the last few years have been encouraging.

Importantly, floricane injury and berry harvest have not been significantly impacted by these applications. Since postemergence (POST) treatments can be made when weeds are visible and thus to areas known to be infested with perennial weeds, cost of these treatments may be significantly lower than broadcast applications to the full block. Additionally, if good to excellent weed control results from these applications, slight crop injury due to the herbicide is more acceptable if it occurs only on selected areas of the field. More reliable crop injury data resulting from applications of these products is needed to document that they are safe for use in raspberry if registrations are to result, however. Treevix (BASF) and Alion (Bayer) are two new herbicides that recently gained federal registrations in certain orchard crops. Initial data in raspberry is promising, with Treevix as a cane burning herbicide similar in activity to Goal (oxyfluorfen) and Alion providing residual control of germinating weed seeds.

Dr. Ed Peachey at Oregon State University is also conducting herbicide work in red raspberry, with both of us conducting preliminary crop safety (nonresidue) trials with IR-4 with Facet. We are also cooperating with Dr. Doug Doohan at Ohio State University on our investigations with Stinger. I am unaware of any weed management projects in raspberry occurring in Idaho or British Columbia.

Relationship to WRRC Research Priority(s): #2 Priority, Weed Management

Objectives (2013): To test several non-labeled herbicides in various sequences or mixtures for control of several perennial weeds in established red raspberries.

Procedures:

Plots will be established in 2013 in established raspberries. Herbicide applications will be made for several combinations of herbicides at cane burning time in early spring (Treevix and Alion) and late spring (Stinger and Facet). A typical application sequence could be Treevix + Alion in April followed by Stinger in late May. Most sequences/combinations of these herbicides will be included in this trial, as well as combinations and sequences with other common residual herbicides such as Sinbar (terbacil), simazine, diuron, and Callisto (mesotrione). Weed control will be evaluated, as will herbicide effects on raspberry yield, berry size, and primocane growth.

Anticipated Benefits and Information Transfer: (100 words maximum)

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:

	2013	2014	2015
Salaries[1]/	$ 1,500	$ 0	$ 0
Time-Slip	$ 1,000	$ 0	$ 0
Operations (goods & services)	$ 500	$ 0	$ 0
Travel[2]	$ 250	$ 0	$ 0
Meetings	$ 0	$ 0	$ 0
Other	$ 0	$ 0	$ 0
Equipment	$ 0	$ 0	$ 0
Benefits[3]	$ 1,345	$ 0	$ 0
Total	**$ 4,595**	**$ 0**	**$ 0**

Budget Details

[1]Salary for A/P scientific assistant Carl Libbey (100% funded by my weed science program).
[2]Travel is for plot establishment, maintenance, and harvest.
[3]Benefits (41.9% for A/P scientific assistant, $629; 71.6% for time-slip help, $716).

2013 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

Project Title: Evaluation of resistance to *Verticillium dahliae* and *Phytophthora rubi* in red raspberry

PI: Patrick Moore, Horticulture, Washington State University, Puyallup Research and Extension Center (WSU-P), 2606 W Pioneer Ave., Puyallup, WA 98371; moorepp@wsu.edu, 253-445-4525.

Co-PIs: Jerry Weiland, Plant Pathology, USDA-ARS, 3420 NW Orchard Avenue, Corvallis, OR 97330; jerry.weiland@ars.usda.gov, 541-738-4062.

Wendy Hoashi-Erhardt, Horticulture, WSU-P, 2606 W Pioneer Ave., Puyallup, WA 98371; wkhe@wsu.edu, 253-445-4641.

Year Initiated <u>2013</u> Current Year <u>2013</u> Terminating Year <u>2014</u>

Total Project Request: Year 1 $6,772 Year 2 $1,826

Other funding sources
Agency Name: USDA-ARS Crop Germplasm Committee
Amt. Requested: $16,434 Awarded: $10,000

Description:
This project will evaluate the response of a range of red raspberry cultivars and selections to Verticillium (*Verticillium dahliae*) and the response of a subset of these cultivars to Phytophthora root rot (*Phytophthora rubi*) both singly and in combination with Verticillium. This project will provide information on the relative susceptibility of red raspberry cultivars grown in Washington.

Justification and Background: Verticillium wilt has generally been considered of low importance relative to Phytophthora root rot in red raspberry (*Rubus idaeus* L.), although it can be a serious disease of black raspberry (*Rubus leucodermis* L.) (Dossett, 2008; Ellis, 1991). However, 'Meeker', the dominant cultivar in the Pacific Northwest, has recently been found to be susceptible to infection by the causal organism *Verticillium dahliae*, showing symptoms of cane wilt and plant mortality (Weiland, unpublished data). Strain variation present within *V. dahliae* may explain the development or introduction of a virulent strain into raspberry fields. Additionally, the recent reduction of planting longevity in major raspberry growing regions indicates an overall decline in soil health and ability to suppress soil-borne pathogens (Gigot, 2011). As soils lose their suppressive qualities, individual pathogens of red raspberry, such as *Phytophthora rubi* and *V. dahliae*, become increasingly important, and disease complexes arising from multiple soil pathogens may kill plants outright or produce sub-lethal effects of low yields, low vigor, or poor fruit quality. The susceptibility of raspberry cultivars and breeding material to verticillium wilt is unknown, as no studies of *V. dahliae* on raspberry appear in the literature. The effect of coinfection by both *P. rubi* and *V. dahliae* is also unknown. Major susceptibilities in common cultivars may make raspberry growers more vulnerable to losses if verticillium wilt becomes a common disease or contributes to overall decline in production regions.

Jerry Weiland is a Co-PI on this grant is a USDA researcher in Corvallis and has studied the effects of *Verticillium dahliae* on red raspberry.

Relationship to WRRC Research Priority(s): This proposal addresses two first-tier priorities of the WRRC: 1) Understanding soil ecology and soil borne pathogens and their effects on plant health and crop yields, and 2) Development of raspberry cultivars that are disease resistant.

Objectives: This study has two objectives: 1) to assess responses to *V. dahliae* in existing raspberry germplasm, and 2) to assess reaction of a subset of raspberry genotypes to combined pressures of *P. rubi* and *V. dahliae*.

Procedures: Thirty-five raspberry genotypes representing important cultivars, breeding material, and core *R. idaeus* accessions from the National Clonal Germplasm Repository (NCGR) will be evaluated (Table 1). Some patented cultivars with high plant sales in the Pacific Northwest are included to assess their susceptibility to verticililum wilt. 'Wakefield' and WSU 1507 will be included in the screening.

Verticillium dahliae (originally isolated from red raspberry cultivar 'Saanich') inoculum is produced using a method adapted from López-Escudero et al. (2007). Briefly, *V. dahliae* is grown on potato dextrose agar covered with a cellophane disk. After 2 weeks, microsclerotia of the pathogen are collected, air-dried, and mixed with sterile sand. The number of microsclerotia/gram of inoculum is then determined and mixed into potting media at rates suitable to obtain a density of 100 microsclerotia/gram before planting with the raspberry genotypes. Potting media is prepared from collected field soil that was passed through a 2-mm-diam sieve, autoclaved, and then mixed with fine vermiculite.

P. rubi (strain ATCC 16184) inoculum will be produced using a method adapted from Gigot (2011). Briefly, *P. rubi* is grown on a mixture of vermiculite, V-8 broth, and oats. After four weeks, the mixture is air-dried, then ground into a powder. Oospore density of the inoculum is determined. Prior to planting, *P. rubi* inoculum is added to the potting media (above) to attain suitable oospore densities.

The raspberry genotypes will be planted and evaluated in potting media with two treatments, 1) a non-inoculated control and 2) inoculated with *V. dahliae*. A subset of eight genotypes will be subjected to two additional treatments, 3) inoculated with *P. rubi* only, 4) inoculated with *V. dahliae* and *P. rubi*. Tissue culture plants are planted into infested or control mixtures in five replications and maintained in a greenhouse.

Plants are rated for overall appearance, shoot growth (stem length), and symptom development (wilting and side shoot formation) at 1 month, 2 months, and 3 months after transplant. Plants are harvested at 3 or 4 months after inoculation. A one-inch section of stem will be plated for recovery of *V. dahliae* and the soil will also be evaluated for changes in *V. dahliae* inoculum density. The roots and shoots are separated, potting mixture washed from roots, and roots and shoots dried to obtain dry weights. The experiment will be performed twice in 2013-2014. Disease information obtained from this study will be transmitted to the NCGR and uploaded to GRIN.

Anticipated Benefits and Information Transfer: Verticillium wilt is a possible emerging problem in red raspberry fields in the Pacific Northwest. This study will provide information on susceptibility to verticillium wilt for red raspberry cultivars grown in the PNW. This information will be used to aid in cultivar selection and assist breeding programs in choosing parent materials. Results will be communicated in progress reports and grower meetings. The information will also be transmitted to the NCGR and uploaded to GRIN.

References:

Dossett, M., J. Lee, and C. Finn. 2008. Inheritance of phenological, vegetative, and fruit chemistry traits in black raspberry. J. Amer. Soc. Hort. Sci. 133:408-417.

Ellis, M.A. 1991. Verticillium wilt. In: Compendium of Raspberry and Blackberry diseases and insects, M.A. Ellis, R.H. Converse, R.N. Williams, and B. Williamson, eds. American Pathological Society, St. Paul, MN.

Gigot, Jessica. 2011. Root health management in raspberry production systems. Ph.D. dissertation, Wash. State Univ., Pullman.

López-Escudero, F.J. and M.A. Blanco- López. 2007. Relationship between the inoculum density of *Verticillium dahliae* and the progress of verticillium wilt of olive. Plant Dis. 91: 1372-1378

Budget

	2013-14	2014-2015	Total
00 Salaries			
Scientific Assistant 0.05 FTE	2,053		2,053
01 Timeslip Labor	990	600	1,590
03 Service and Supplies	2,000	568	2,568
04 Travel	600	600	1,200
07 Benefits			
Scientific Assistant	1,033		1,033
Timeslip	96	58	154
Total	$6,772	$1,826	$8,598

Service and supplies are for growing plants and preparing inoculum
Travel between Corvallis and Puyallup to work on project

Table 1. Thirty-five *Rubus* genotypes proposed for evaluation for response to V. dahliae and P. rubi

Clone	V. dahliae evaluation	P. rubi evaluation
Algonquin	X	
Autumn Bliss	X	
Bababerry	X	
Boyne	X	
Cascade Bounty	X	X
Cascade Delight	X	
Centennial	X	
Chemainus	X	X
Cherokee	X	
Chief	X	
Chilcotin	X	
Chilliwack	X	
Citadel	X	
Cowichan	X	X
Dinkum	X	
Glen Prosen	X	
Haida	X	
Heritage	X	
Killarney	X	
Latham	X	
Malahat	X	
Meeker	X	X
Munger	X	
Newburgh	X	X
Nootka	X	
Puyallup	X	
Qualicum	X	
Reveille	X	
Royalty	X	
Saanich	X	
Skeena	X	
Sumner	X	X
Tulameen	X	X
Washington	X	
Willamette	X	X

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	$138,424	2012-2014	Small Fruit Breeding in the Pacific Northwest
Moore, P.P. and Hoashi-Erhardt	Washington Red Raspberry Commission	$65,000	2012-2013	Red Raspberry Breeding, Genetics and Clone Evaluation
Moore, P.P. and Hoashi-Erhardt	Washington Strawberry Commission	$17,100	2012-2013	Genetic Improvement of Strawberry
Moore, PP, Weiland, Hoashi-Erhardt	USDA, Crop Germplasm Committee	$10,000	2012-2014	Evaluation of resistance to *Verticillium dahliae* and *Phytophthora rubi* in red raspberry
Moore, P.P. and Hoashi-Erhardt	Oregon Strawberry Commission	$4,000	2012-2013	Genetic Improvement of Strawberry
Moore, P.P. and Hoashi-Erhardt	Organic Farming Research Foundation	$38,053	2012-2014	Breeding day-neutral strawberry cultivars for organic production in the Pacific Northwest

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	$68,000	2013-2014	Red Raspberry Breeding, Genetics and Clone Evaluation
Moore, PP, Weiland, Hoashi-Erhardt	Washington Red Raspberry Commission	$8,598	2013-2015	Evaluation of resistance to *Verticillium dahliae* and *Phytophthora rubi* in red raspberry
Moore, P.P. and Hoashi-Erhardt	Washington Strawberry Commission	$37,000	2013-2014	Genetic Improvement of Strawberry

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: 2012
Accomplishments:
Advanced Selections/ possible release. A selection has been identified that machine harvests well, is root rot tolerant and raspberry bushy dwarf virus (RBDV) resistant. Yields at WSU Puyallup and in machine harvesting trials have been good. Propagation material was sent to nurseries fall 2011 for propagation prior to possible release, but only a limited number of plants will be available in 2013, so a release request will not be proposed in 2012. This selection and two other selections were planted in larger test plantings for IQF evaluations with cooperating growers in 2012 and a "baby" crop is scheduled to be harvested in 2013. These selections could be released as new cultivars after evaluation.

Crosses/seedlings/selections. In 2012, 77 raspberry crosses were made for cultivar development and germplasm purposes. An additional 12 crosses were made for research studies. Seedlings from crosses made in 2011 were planted in the field at WSU Puyallup. Sixty-five selections were made in 2012 among the 7,200 raspberry seedlings planted in 2010. Thirty-seven of the selections have a RBDV resistant parent and an additional 9 selections have both parents RBDV resistant. Seventy-five percent of the selections had a parent that is known to be tolerant of root rot.

Machine Harvesting Trials. A new machine harvesting planting to evaluate machine-harvestability of raspberry selections was established with a cooperating grower with 90 WSU selections, 10 BC selections and two reference cultivars. This planting will be machine harvested in 2014 and 2015. The machine harvesting plantings established in 2009 and 2010 were evaluated weekly during the 2012 season beginning July 5. There were 12 selections in the 2009 and 2010 plantings that exhibited traits of high yields, excellent plant vigor, good fruit integrity, and low incidence of harvested green berries. The most promising of these selections will be planted with a cooperating grower for additional evaluation. Some WSU selections may be planted in grower trials, given successful plant propagation.

Selection Trial Puyallup. A replicated planting was established at WSU Puyallup of six WSU selections, one BC selection and two cultivars in replicated plots and 10 WSU selections in observation plots. This planting will be harvested in 2014 and 2015. A new root rot planting was established with seven WSU selections and three cultivars. The replicated planting established in 2009 was hand harvested for the second time in 2012 (Table 1). WSU 1957 had the highest yield in 2012 and the highest two year total. WSU 1507 had the highest yield in 2011 and the second highest two year total. The replicated planting established in 2010 was hand harvested for the first time in 2012 (Table 2). WSU 2115 had the highest yield and largest fruit weight. WSU 2029 had an extremely late ripening season, beginning July 26, and although harvest was discontinued August 6, had ripe fruit through the beginning of September.

Publications/Presentations:
July 18, 2012. Machine Harvesting Open House. Lynden, WA

Ward, J.A., W.E. Boone, P.P. Moore and C.A. Weber. 2012. Developing Molecular Markers for Marker Assisted Selection for Resistance to *Raspberry Bushy Dwarf Virus* (RBDV) in Red Raspberry. Acta Hort 946:61-66.

Moore, P.P. and W.K. Hoashi-Erhardt. 2012. Effects of *Raspberry Bushy Dwarf Virus* on Fruit Traits in Five Raspberry Cultivars. Acta Hort 946: 263-266.

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.

Moore, P.P. and C. Kempler, Section Editors. 2012. Raspberry. In Finn, C.E. and J.R. Clark (Eds.) Register of Fruit and Nut Cultivars List 46. HortScience 47:555-556.

Table 1. 2012 harvest of 2010 planted raspberries, Puyallup, WA.

	Yield (t/a)		Fruit weight (g)		Fruit rot (%)		Fruit firmness (g)		2012 harvest: Dates for percentage cumulative yield 5%		50%		95%		Length of harvest season (d)	
WSU 2115	14.4	a	6.64	a	6.6	a	90	b	6/26	e	7/6	de	7/19	d	23	b-d
Meeker	12.8	ab	3.60	cd	6.5	a	62	c	7/4	cd	7/18	ab	7/30	ab	26	a-c
WSU 1741	10.3	a-c	3.32	cd	5.6	a	69	c	6/26	e	7/12	c	7/26	b-d	30	ab
C Bounty	10.1	a-c	3.95	c	7.9	a	60	c	6/30	de	7/13	bc	7/28	a-c	28	a-c
Willamette	8.8	a-c	3.80	cd	6.3	a	75	bc	6/24	e	7/5	e	7/19	d	26	a-c
WSU 1511	8.8	a-c	4.23	bc	6.4	a	62	c	7/11	bc	7/20	a	8/2	a	22	cd
WSU 1550	7.2	a-c	2.83	d	7.6	a	67	c	6/27	de	7/13	bc	7/28	a-c	31	a
WSU 1750	7.1	a-c	3.82	cd	6.4	a	63	c	7/14	b	7/22	a	7/31	ab	17	d
WSU 1626	6.7	bc	5.06	b	5.2	a	70	c	6/28	de	7/11	cd	7/22	cd	24	bc
WSU 2029**	3.5	c	5.04	b	2.7	a	108	a	7/26	a	-		-		-	
	9.0		4.23		6.1		73		7/3		7/13		7/26		25	

Three replications of 3 plant plots.

Means followed by the same letter within a column are not significantly different using Tukey's Studentized Range (HSD) Test, P - 0.05.

** WSU 2029 harvest discontinued August 6. Ripe fruit on the plant through the beginning of September, but not harvested.

Table 2. 2011 and 2012 harvest of 2009 planted raspberries, Puyallup, WA

	Yield (t/a)			Fruit weight (g)		Fruit rot (%)		Fruit firmness (g)	
	2012	2011	Total	2012	2011	2012	2011	2012	2011
WSU 1957	11.0 a	4.5 ab	15.5 a	3.03 e-h	3.00 de	7.2 b-d	8.2 a-d	68 d-h	53 c
WSU 1507	8.0 a-c	5.2 a	13.1 ab	3.71 d-f	3.77 bc	3.8 d	11.8 a-c	70 d-h	90 bc
Meeker	8.9 ab	3.3 a-c	12.2 a-c	3.13 e-h	2.82 de	4.5 d	7.0 b-d	71 c-h	65 bc
WSU 1605	7.6 a-c	4.4 ab	12.0 a-d	5.01 bc	4.45 b	4.3 d	7.4 a-d	78 b-f	118 b
WSU 1952	7.0 a-c	4.8 ab	11.7 a-d	2.71 gh	2.83 de	3.5 d	6.0 d	66 f-i	72 bc
C Bounty	8.1 a-c	3.5 a-c	11.7 a-d	3.71 d-f	3.25 c-e	11.7 ab	12.8 a	73 b-g	45 c
WSU 1956	7.6 a-c	3.5 a-c	11.1 a-d	3.81 de	2.79 de	2.8 d	3.6 d	78 b-e	79 bc
Willamette	6.9 bc	4.0 a-c	10.8 a-e	3.47 d-g	2.88 de	4.9 cd	7.2 b-d	83 bc	72 bc
WSU 1747	6.0 bc	2.4 a-c	8.4 b-e	6.81 a	5.77 a	14.1 a	12.2 ab	132 a	214 a
WSU 1950	5.0 bc	3.0 a-c	8.0 b-e	2.42 h	2.67 e	1.8 d	5.9 d	59 hi	47 c
Ukee	6.3 bc	0.9 c	7.2 c-e	3.31 d-h	3.07 c-e	4.0 d	12.2 ab	68 d-h	49 c
WSU 1629	5.2 bc	1.7 bc	6.9 de	5.10 b	4.49 b	5.2 cd	6.4 cd	83 b	111 b
WSU 1610	4.2 c	1.7 bc	5.9 e	4.10 cd	3.54 cd	5.6 b-d	8.2 a-d	80 b-d	99 bc
WSU 1713	7.7 a-c			3.14 e-h		1.9 d		64 g-i	
WSU 1958	6.9 bc			2.86 f-h		4.4 d		67 e-h	
WSU 1951	6.7 bc			2.39 h		5.6 b-d		55 i	
WSU 1030	6.3 bc			3.82 de		10.9 a-c		75 b-g	
WSU 1568	4.8 c			4.13 cd		3.8 d		66 f-i	
	6.9	3.3	10.3	3.70	3.49	5.5	8.4	74	86

Three replications of 3 plant plots.

Means followed by the same letter within a column are not significantly different using Tukey's Studentized Range (HSD) Test, P - 0.05.

Table 2 continued. 2011 and 2012 harvest of 2009 planted raspberries, Puyallup, WA

	2012 harvest				2011 harvest			
	Dates for percentage cumulative yield			Length of harvest season (d)	Dates for percentage cumulative yield			Length of harvest season (d)
	5%	50%	95%		5%	50%	95%	
WSU 1957	6/29 jk	7/12 gh	7/27 d-h	28 ab	7/5 fg	7/14 f	7/27 e	21 ab
WSU 1507	7/2 g-j	7/14 e-h	7/28 b-h	26 a-d	7/6 e-g	7/18 d-f	8/1 a-e	26 a
Meeker	7/4 f-i	7/16 b-g	7/30 a-g	27 a-d	7/8 d-g	7/20 c-e	8/2 a-d	25 ab
WSU 1605	7/11 a-d	7/20 a-c	7/31 a-e	21 c-e	7/17 ab	7/25 ab	8/4 a-c	18 ab
WSU 1952	6/30 h-j	7/12 gh	7/26 d-h	26 a-d	7/7 d-g	7/16 ef	7/30 c-e	23 ab
C Bounty	6/29 i-k	7/14 c-h	7/29 a-g	30 a	7/10 c-f	7/18 d-f	7/30 c-e	20 ab
WSU 1956	7/11 a-c	7/22 ab	8/2 a-c	21 c-e	7/13 a-d	7/26 a	8/5 ab	23 ab
Willamette	6/25 k	7/5 i	7/20 j	25 a-e	7/4 g	7/15 ef	7/27 e	23 ab
WSU 1747	7/14 a	7/23 a	8/2 ab	19 e	7/18 a	7/27 a	8/5 ab	18 ab
WSU 1950	7/4 e-h	7/15 c-h	7/25 g-j	21 c-e	7/12 b-e	7/20 cd	7/29 de	18 ab
Ukee	7/8 c-f	7/19 a-e	7/31 a-f	23 b-e	7/15 a-c	7/22 bc	8/1 a-e	17 b
WSU 1629	7/13 ab	7/23 a	8/3 a	20 de	7/16 a-c	7/27 a	8/6 a	21 ab
WSU 1610	7/6 d-g	7/20 a-d	7/30 a-g	24 a-e	7/8 d-g	7/21 cd	7/31 b-e	23 ab
WSU 1713	7/9 b-e	7/18 a-f	8/1 a-d	23 b-e				
WSU 1568	7/4 f-i	7/14 d-h	7/25 f-i	22 c-e				
WSU 1951	6/30 h-j	7/13 f-h	7/27 c-h	27 a-c				
WSU 1030	6/29 jk	7/11 gh	7/21 ij	22 b-e				
WSU 1958	6/29 i-k	7/10 hi	7/23 h-j	24 a-e				
	7/4	7/15	7/28	24	7/11	7/21	8/1	21

Three replications of 10 foot plots.

Means followed by the same letter within a column are not significantly different using Tukey's Studentized Range (HSD) Test, P - 0.05.

PROJECT: 13C-3755-5641
TITLE: Red Raspberry Breeding, Genetics and Clone Evaluation
CURRENT YEAR: 2013
Proposed Duration: continuing

PI: Patrick P. Moore, Scientist
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

Project Request: $68,000 for 2013-2014

Other funding sources: USDA/ARS Northwest Center for Small Fruits Research
$138,424for 2012-2014 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 2012 will be sown in 2012-2013. The goal will be to plant 108 plants for each cross.

3. Selections will be made among the seedlings planted in 2011. 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 2010 and 2011will be harvested in 2013. 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 2010 and 2011 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 technician support for the program.

The funds requested will be used for timeslip labor; field, greenhouse, and laboratory supplies; and travel to research plots and to grower meetings to present results of research.

The proposed budget includes $5,000 (as timeslip labor plus benefits) for summer funding for a graduate student that is working on DNA markers for RBDV resistance. Funding for the school year will be from other sources. The proposed budget also includes $3,000 for farm service fees.

Budget:	**2012-2013**	**2013-2014**
00 Salaries		
Ag Res Tech 2 (0.05) FTE	2,096	2,075
01 Timeslip Labor	37,562	37,562
03 Service and Supplies	16,911	19,910[1]
04 Travel	4,000	4,000[2]
07 Benefits		
Timeslip	3,606	3,606
Ag Res Tech 2	825	847
Total	**$65,000**	**$68,000**

[1] Includes: Field, greenhouse, and laboratory supplies; $3,000 for farm service 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 2010 – Honcoop Farms	$3,000
Machine harvesting trial established in 2011 – Honcoop Farms	$3,000

Maintenance of test plantings

Machine harvesting trial established in 2012 – Honcoop Farms	$3,000

Establishment and maintenance of new test planting

Machine harvesting trial to be established in 2013

Will work with the WRRC to identify a suitable grower for the 2013 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	$138,424	2012-2014	Small Fruit Breeding in the Pacific Northwest
Moore, P.P. and Hoashi-Erhardt	Washington Red Raspberry Commission	$65,000	2012-2013	Red Raspberry Breeding, Genetics and Clone Evaluation
Moore, P.P. and Hoashi-Erhardt	Washington Strawberry Commission	$17,100	2012-2013	Genetic Improvement of Strawberry
Moore, PP, Weiland, Hoashi-Erhardt	USDA, Crop Germplasm Committee	$10,000	2012-2014	Evaluation of resistance to *Verticillium dahliae* and *Phytophthora rubi* in red raspberry
Moore, P.P. and Hoashi-Erhardt	Oregon Strawberry Commission	$4,000	2012-2013	Genetic Improvement of Strawberry
Moore, P.P. and Hoashi-Erhardt	Organic Farming Research Foundation	$38,053	2012-2014	Breeding day-neutral strawberry cultivars for organic production in the Pacific Northwest

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	$68,000	2013-2014	Red Raspberry Breeding, Genetics and Clone Evaluation
Moore, PP, Weiland, Hoashi-Erhardt	Washington Red Raspberry Commission	$8,598	2013-2014	Evaluation of resistance to *Verticillium dahliae* and *Phytophthora rubi* in red raspberry
Moore, P.P. and Hoashi-Erhardt	Washington Strawberry Commission	$37,000	2013-2014	Genetic Improvement of Strawberry

Washington Red Raspberry Commission
Progress Report Format for 2012 Projects

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: 2012

Accomplishments:
Advanced selections/varieties planted in 2012: WSU 1507, WSU 1912, WSU 1948, Rudi.
Participating propagators & what they provided (materials paid for by the commission):

- **North American Plants**: WSU 1912—1050 TC plants, WSU 1948—950 TC plants
- **Northwest Plants/Enfield Farms**: WSU 1507—775 TC plants, Rudi—800 TC plants
- **Norcal Nursery (Sakuma Bros.)**: Rudi—325 bare root plants.

Participating growers & selections in their trials:

- **Ralph Minaker** (225 of each) : WSU 1507, WSU 1912, WSU 1948, Rudi (bare root)
- **Enfield Farms** (250 of each): WSU 1507, WSU 1912, WSU 1948, Rudi (TC)
- **Sakuma Farms** (200 of each) : WSU 1507, WSU 1912, WSU 1948
- **George Hoffman** (100 of each) : WSU 1507, WSU 1912, WSU 1948, Rudi (bare root)
- **Don Sturm Farm:** WSU 1507(150 plants), WSU 1912 (275 TC plants) , WSU 1948 (175 TC plants)

Regional distribution of trials

- **Ralph Minaker :** Whatcom County, Everson area.
- **Enfield Farms:** Whatcom County, West Lynden area.
- **Sakuma Farms:** Skagit County, Mt. Vernon area.
- **George Hoffman:** SW Washington, Clark County, Ridgefield area.
- **Don Sturm Farm:** Corbett, OR. *We had a plant surplus which were offered to Don. His location in the east Willamette valley and higher elevation offered a different environmental setting that the other sites.*

Results:

- Establishing the framework, recruiting participants, getting the first plants in the ground.

New 2012 on Farm plantings—Minaker farm and Enfield Farm
Publications: none

Current & Pending Support

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount To PCM	Effective and Expiration Dates	% of Time Committed Per year	Title of Project
	Current:				
T. Peerbolt	WRRC	10,200	1/1/12-12/31/12	10	Evaluating the Feasibility of Coordinated Regional on-farm Trials of Advanced Raspberry Selections
T. Walters	WSU	20,508	9/1/10-8/31/14	3	Managing Soil-borne Diseases of Raspberry
V. Walton	USDA	201,908	9/1/10-2/28/15	10	Biology and Management of Spotted Wing Drosophila on Small and Stone Fruits
T. Peerbolt	NCSFR	32,554	9/14/12-9/30/13	10	Evaluating the Feasibility of Coordinated Regional on-farm Trials of Advanced Raspberry & Blackberry Selections
T. Peerbolt	ORBC	11,500	7/1/12-6/30/13	10	Coordinated Regional on-farm Trials of Advanced Blackberry and Raspberry Selection
T. Peerbolt	WRRC, WSC, WBC, OBC, RIDC, FVSGA, NABC, BCBBCouncil, ORBC, OSC	19,500	1/1/12-12/31/12	20	Continuation of a weekly email IPM Newsletter for Small Fruit Growers and Related Industry Personnel
	Pending:				

2013 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—Second Year

PI:
Tom Peerbolt
Organization: Peerbolt Crop Management
Title: Co-owner and Senior Researcher
Phone: 503-289-7287
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** 2013 **Terminating Year** 2013

Total Project Request: Year 1 $ Year 2 $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 over a larger geographical area.

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.

Justification and Background:
The northwest raspberry breeding programs have been a cornerstone of the industry's success. Their 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 our 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 2013.

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 two (2013) procedures

- Establish new plantings following procedures similar to those used in year one (2012).
- Spring evaluation will be made of plant health/winter damage of the year one plantings.
- Evaluations will be made of the first harvest of the year one plantings.
- Evaluations will be made in the fall to determination whether to continue for another year's data of the year one 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 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: *Indirect or overhead costs are not allowed* unless specifically authorized by the Board

	2013	**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.

Project Title: Fungicide Resistance in Botrytis in Washington Berries	
2) Details of Project: Crop/Site: Raspberry/Blueberry Chemical: Several Pest Management Issue: Resistance to fungicides Pest: Botrytis cinerea	**4) Research Lead:** Alan Schreiber, ADG, Inc. aschreib@centurytel.net
5) Project Category: Check all that describe the focus of your project. Registration ____% Non Registration: 100 % ___Efficacy Trial ____ Integrated Pest Management ___ GLP ___ Phytotoxicity Study X Resistance Management X non-GLP ___ Residue Study ___ Other:	
6) Project Duration Start Date : February 1, 2013 End Date October, 30, 2013	
7) Total Project Cost $ 11,300 **WRRC Request** $ 3,000 **Co-funding** $ 8,300	
Project Summary: Raspberry and blueberry suffer heavily from Botrytis, which has a history of developing resistance to fungicides. Growers treat each crop three to six times per season with a limited number of products. The number of products available is further limited by MRL and label restrictions. The same set of products is used for its control on both crops. 2011 failures in the field raised the specter of resistance. An internal research project of an agrichemical company conducted in 2012 indicated that multiple fungicides may have resistance issues on raspberries. We propose to sample raspberry and blueberry fields throughout western Washington to survey for resistance to a range of fungicides. This information is expected to result in a revision in disease control programs for Washington berries and may result in pursuit of emergency exemptions for both crops.	

Description of Problem. Botrytis cinerea, 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.

On blueberry, it survives as sclerotia (resistant survival structure) and dormant mycelium on dead twigs of bushes and prunings. It also overwinters as a saprophyte on dead organic matter and dead plant parts in or on the soil surface. In spring, these tissues produce vast numbers of spores during wet periods. Spores spread primarily by wind but also by splashing water. Cultivars that tend to retain floral structures over a long period are more susceptible. Also, branch tips killed by low winter temperatures are easily infected. Green fruit can rot when rains continue into the late spring and early summer. Infection is more likely on fruit that retains old floral tissue.

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. (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 Handbooks states this about Botrytis on berries "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 Clemons, 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. The results from this informal survey have not been released but based on feedback from Clemons and a cooperator, a significant number of samples tested positive for a high degree of tolerance to one or more modes of action.

Pristine (boscalid+pyraclostrobin), Captan, Elevate (fenhexamid) and Switch (cyprodinil+fludioxonil) are the four products used for Botrytis control. Due to MRL issues, some products have limited use (e.g. berries going to Canada cannot have any captan residues.) Anecdotal information indicates that Elevate and Switch may have tolerances issues in Washington. Currently growers try using all four products (some can only use three products) 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 could mean a significant problem; the loss of two products would cause a crisis in the industry. Documentation of resistance would provide the industry with immediate grounds for a Section 18 for fenpyrazamine, fluopyran or even penthiopyrad, three products that are in the IR-4 registration program for Botrytis control in berries. If resistance can be documented in the early season, there is the potential for a crisis exemption using the Section 18 process.

A recurring theme in the Washington berry industry is that we lack access to a plant pathologist, making collecting, generating and disseminating data on berry diseases virtually impossible.

Value of the Industry. The Washington blueberry and raspberry industries were valued at $117 million and $54 million, respectively, in 2011 in the recently released 2012 WASS report.

Losses due to Botrytis. We have no way to quantify the loss, but we expect collectively it is in the millions of dollars, particularly if cost of control is included.

Acres Impacted. All berry acres in western Washington are impacted, which represents 95% of raspberries and 70% of blueberries in the state of Washington.

Aggregate impact to the industry. After SWD, Botrytis is considered the most significant pest problem in the berry industry. While the problem is important now, if resistance develops to one or two of the products currently being used, it could be catastrophic.

Effect of the problem on the industry. Growers suffer economic losses annually but this loss is moderated through a combination of chemical and non-chemical control tactics. Loss of fungicides to resistance is expected to result in large economic damage to the berry industry.

Effect of the problem on consumers, society, environment, non-target species or human health. We see this more as economic viability issue to our industry, however, we believe it is society's/the environment's best interest to prevent the development of resistance. Development of resistance has been repeatedly shown to result in significantly increased use of pesticides.

Description of alternative control measures and why they are not effective or additional information on the specific need. Growers currently engage in a number of alternative control tactics such as annually prune to remove infected twigs and to open canopy for good air circulation; space plants for good air circulation and quick drying; adjust timing and/or frequency of overhead irrigation to keep aboveground portions of the plant dry; avoid late-season fertilization; and, pick fruit at correct stage of maturity and move harvested fruit to cold storage as soon as possible. However even with these tactics, intensive fungicide use is necessary.

Funding Categories. Category C - Significance to Local or Regional Economy
II. Resistance management
IV. Registration of an additional pest control tactic

Project Description. *Objective 1.* Sample Botrytis infections in berry fields in western Washington and screen for tolerance. *Objective 2.* Use information to revise Botrytis berry control programs.

We propose to use local crop advisors, growers/industry representatives to collect raspberry (June/July) and blueberry (July/August/September) Botrytis infected fruit. The samples will be shipped to Jim Adaskavig (UC Davis) who has agreed to test the fruit for tolerance to berry fungicides. Counties to be sampled include Clark, Lewis, Thurston, King, Skagit and Whatcom. Other counties could be included, but the aforementioned were selected due to their large berry acreage or knowledge of good cooperators. While blueberries and raspberries are the target of this project, berry growers also grow strawberries which have very similar problems. It is expected that a few strawberry samples would be collected and submitted. Our goal is to submit 200 samples of fruit. It is easy to find infected fruit, but we hope to find Botrytis on plants early in the season and test it for resistance. If resistance can be documented early enough, then it may be possible to use this information for a Section 18. While this is a possibility, it is premature to create the expectation that this will happen.

Budget

Expenditure	WSCPR (Request)	Co-funding (CASH or IN-KIND)			TOTAL COST
		Source: WBC	**Source:**WRRC	**Source:WBC**	
		Amount (CASH)	**Amount (CASH)**	**Amount (in-kind)**	
Salaries1					
Employee Benefits					
Samplers/Shipping	5,000	1,000	1,000		7,000
Travel2					
Basic supplies				300	300
UC Davis		2,000	2,000		4,000
Total	5,000	3,000	3,000	300	11,300

We plan to contract with local field reps/crop advisors to collect the fruit (including Tom Peerbolt for SW Washington, Whatcom County Farmers Coop, etc. in Whatcom County, etc.). Schreiber will collect samples for Thurston, King and Skagit counties.\

$4,000 will be provided to U.C. Davis for the sample evaluations.

Has this budget been reviewed for accuracy? Yes By Whom? Stacey Hill

Project No.: 13C-3443-5370

Title: Chemical control of spotted wing drosophila, *Drosophila suzukii* (Matsumura) in western Washington red raspberry, utilizing local monitoring and phenology between fruit ripening and infestation levels

Year Initiated: 2009 **Current Year:** 2010-2011 **Terminating Year:** 2012

Personnel: **Lynell K. Tanigoshi**, Entomologist[1]
Beverly S. Gerdeman, Research Associate, Entomology[1]
G. Hollis Spitler, Agricultural Research Technician[1]

Collaborators: **Thomas Walters**, Small Fruit Horticulture Program[1]
[1]WSU-Mount Vernon NWREC

Accomplishments: Two follow-up field residual trials design to corroborate and clarify 2011 mortality levels for SWD adults, failed to provide statistically significant results that provided growers with general guidelines for their insecticide rotations within and between different MOA chemistries. Results indicated 50 ± 23.3 percent adult mortality for Mustang Max at 1 DAT and no mortality at 8 DAT is extremely problematic. Study of the ovarian development of SWD provided new knowledge about the seasonal reproductive status of fluctuating SWD populations in northwestern Washington. Presence of SWD in the field did not always coincide with egg-laying capacity. Topical applications of Brigade, Mustang Max, Actara and experimental Voliam flexi and Cyazypyr provided a high level of clay colored weevil mortality/morbidity by 4 DAT. The latter new MOA chemistry is more effective when ingest by root weevils when they encounter continued exposure to dried residues on fruit or foliage under field conditions. Cyazypyr will be supported for an IR-4 residue project.

Results:

Field-aged residual trials for SWD control

Field aged insecticide residual studies were conducted on foliage similar to our 2011 trials to measure adult SWD contact mortality on primocane foliage. We feel residues on foliage are better indicators of potential mortality rates than on fruit surfaces. Canopy foliage provides larger surface areas for high-pressure sprayer coverage that will mitigate resting and feeding sites for adults between their egg-laying activity. Applications were applied with a Spray Systems® CO_2 backpack sprayer equipped with a 36 inch boom equipped with 4 TeeJet® 8002VS flat fan nozzles. This unit will deliver 96 gal/acre to run off at 40 psi. All applications included the adjuvant MSO at 0.0025% v/v. Eleven treatment applications were applied in a 3' x 9' swath at chest height on the westside of 10'x9' plots. Treatments were made on 16 and 28 August 2012 in a 7 year-old 'Meeker' field at the WSU REC, Mount Vernon. Posttreatment evaluations were made by sampling 4 random, mature primocane leaflets per plot from the spray swath. A leaflet was placed topside up in a disposable 100x15 mm Petri dish with a moisten cotton dental wick, 5 mm^3 of diet media and 5 even-aged SWD adults from our lab colony. These replicated treatment units were evaluated for adult mortality after 24 hr. Random leaf cohorts were taken daily out to 8 days for the multiple treatments and exposed to new SWD adults until <50% mortality occurred for respective treatments. These data provided adult SWD mortality responses to field aged, contact/ingestion residues for field rates of registered and experimental/unlabeled insecticides.

Registered insecticides evaluated for use on strawberries for Washington included:
Brigade WSB (bifenthrin) @ 16 oz/acre (0.1 lb(AI)/acre; Danitol 2.4 EC (fenpropathrin) @ 21.3 fl oz/acre (0.4 lb(AI)/acre; Mustang Max (zeta cypermethrin) @ 4 fl oz/acre (0.025 lb(AI)/acre; Entrust 2SC (spinosad) @ 6.4 fl oz/acre (0.01 lb(AI)/acre; Malathion (Malathion) 8 @ 2 pts/acre (2.0 lb(AI)/acre; Delegate WG (spinetoram) @ 6 oz/acre (0.0938 lb(AI)/acre. Unlabeled insecticides trials were: Brigadier (bifenthrin, imidacloprid) @ 6.14 fl oz/acre (0.048 lb(AI)/acre imidacloprid, 0.048 lb(AI)/acre); Cyazypyr (cyantraniliprole) @ 20.5 fl oz/acre + NIS; Endigo ZC (lambda-cyhalothrin, thiamethoxam) @ 4.5 fl oz/acre (0.08 lb(AI)/acre lambda-cyhalothrin, 0.05 lb(AI)/acre thiamethoxam); Leverage 360 (beta-cyfluthrin, imidacloprid) @ 3.2 fl oz/acre (0.025 lb (AI)/acre beta-cyfluthrin, 0.125 lb(AI)/acre imidacloprid) and Warrior II (lambda-cyhalothrin) @ 1.92 fl oz/acre (0.03 lb(AI)/acre).

Because of unexplained variability between the two different trials for adult SWD mortality measured for the same insecticide, the means for both trials were combined and SEM's determined and analyzed for mean separation with ANOVA. We provisionally set a mortality threshold at 90% for SWD adults incarcerated in Petri dish arenas with a treated raspberry leaflet for 24 hours. Given the experimental design used for this field-lab bioassay, none of the 11 insecticides trialed provided 90% contact morality for adults exposed for a 24 hour period (Tables 1-2). Danitol (84%) and unlabeled Warrior II (82%) exceeded 80% mortality at 1 DAT. Compared with last year's leaf residue trials, all of the known insecticides tested showed activity to adult SWD. Compared with a similar experimental design on blueberry foliage this year, results for red raspberry foliage were significantly lower for the same insecticide/rate and effective DATs. This work needs to be vigorously repeated next season to tighten variability within treatment replicates as well as percent mortality at specific DATs that should be consistently above a 90% threshold for leaf residues to 7 DAT. This empirically determined interval is affected by machine harvest picking interval in Washington's processing cultivars as well as PHI and market destinations.

Table 1. Efficacy of SWD insecticides registered for use on red raspberry

		Percent Mortality		
Treatment	Rate/acre	1 DAT	3 DAT	8 DAT
Brigade WSB	16 oz	42.5def	61.3bc	22.5cde
Danitol 2.4 EC	21.3 fl oz	83.8a	81.3a	25cd
Mustang Max	4 fl oz	49.6abcd	15bc	0e
Malathion 8	32 fl oz	77.abc5	52.5a	50ab
Delegate WG	6 oz	28.8efg	6.7c	0e
Entrust 2 SC	6.4 fl oz	12fg	0c	0e
Untreated check		5g	0c	3e

Mean within columns followed by the same letter are not significantly different
(Fisher's Protected LSD, P<0.05), PRC ANOVA SAS.

Table 2. Efficacy of unlabeled insecticides on SWD on red raspberry

Treatment	Rate/acre	Percent Mortality 1 DAT	3 DAT	8 DAT
Warrior II	1.92 fl oz	81.6ab	51.3a	53.2ab
Brigadier	6.14 fl oz	12.1fg	10c	0e
Endigo ZC	4.5 fl oz	51cde	43.3ab	31.4bc
Leverage 360	3.2 fl oz	70.4abcd	61.8a	69a
Cyazypyr	20.5 fl oz	33.6efg	2.1c	0e
Untreated check		5g	0c	3.6e

Mean within columns followed by the same letter are not significantly different (Fisher's Protected LSD, $P<0.05$), PRC ANOVA SAS.

Clay colored weevil bioassay

Clay colored weevils (CCW) were collected with beat trays from the Northwood area of Lynden from a first year 'Meeker' planting on 14 May 2012. Contact-topical treatments consisted of Actara™ (thiamethoxam at 3 oz/acre), Brigade 2EC (bifenthrin at 6.4 fl oz/acre), Mustang Max (zeta cypermethrin at 4 fl oz/acre) and unlabled Avaunt (indoxacarb at 6 oz/acre), Leverage 2.7 (imidacloprid/cyfluthrin at 3.75 fl oz/acre), Voliam flexi (thiamethoxam/chlorantraniliprole at 7 oz/acre), non-registered Cyazypyr 10 SE (cyantraniliprole at 20.5 fl oz//acre + MSO) and an untreated check. Treatment arenas consisted of an individual red raspberry leaflet placed topside up in a 100x15 mm Petri dish. Each treatment was replicated 3 times with 5 CCW/dish with a moistened 0.5' long cotton dental sick. These arenas were treated with 1 ml of the recommended field rate for each product in the equivalent rate of 100 gal/acre with a Precision Potter Spray Tower at 15 psi. These arenas were held at lab temperature in trays under semi-dark conditions. Adult mortality was assessed by poking individuals with a dissecting probe to determine dead, moribund or feigning dead weevils at 24 hour intervals to 4 DAT. The results of two treatment dates, 17 and 23 May were combined and reported below.

After 1 day posttreatment, all CCW treated with Brigade, Mustang Max and experimental Leverage were dead (Table 3). The results for the two pyrethroids further support our extension recommendations to apply them as early spring basal applications or as foliar sprays during bud break and the formation of fruiting laterals. These applications would provide topical and contact/stomach modes of entry to adult feeding CCW. Actara is a slower acting product and performed commensurate with the unlabeled package mix Voliam flexi. Some of the Actara treated adults scored dead or moribund at 2 DAT recovered on 4 DAT. At 4 DAT, Avaunt provided equivalent level of control with Actara and Voliam flexi as well. Cyazypyr showed significantly lower levels of control and variability between replicates because many of the weevils were scored as moribund or dying. Cyazypyr provides faster knockdown when it is ingested compared with a topically applied treatment. However, one must remember that a topically exposed CCW in the field would be re-exposed to residues on the canes or when they feed on contaminated buds and foliage that should be enough to provide complete mortality. The Czazypyr/Rynaxypyr insecticides represent a unique MOA insecticide (Group 28) that will be supported for an IR-4 residue project in caneberries. Also because DuPont has indicated that Cyazypyr does not have MRL issues like Avaunt has with Canada.

Table 3. Clay color weevil topical bioassay on red raspberry, 2012

		Percent Mortality		
Treatment	Rate/acre	1 DAT	2 DAT	4 DAT
Brigade 2 EC	6.4 fl oz	100a		
Mustang Max	4 fl oz	100a		
Actara	3 oz	63.3b	96.7a	80a
Avaunt	6 oz	40bc	43.3b	90a
Leverage 2.7	6.4 fl oz	100a		
Voliam flexi	7 oz	b	83.3a	93.3a
Cyazypyr 10 SE	20.5 fl oz	cd	40b	50b
Untreated check		0d	0c	0c

Mean within columns followed by the same letter are not significantly different (Fisher's Protected LSD, P<0.05), PRC ANOVA SAS.

Spotted wing drosophila reproductive study

Reproductive readiness of *Drosophila suzukii* (Matsumura) is currently based solely on their presence in traps. However appearance of females in traps does not necessarily correspond to oviposition capability (Gerdeman 2012 unpublished data). We have begun to analyze the ovarian condition of female spotted wing drosophila from trap samples to better understand their phenology and life history in the Pacific Northwest cropping cycles. While *D. melanogaster* is closely related and a perfect reference animal for SWD with voluminous literature, the bulk of its' research focuses on genetics. Literature on drosophila internal morphology is primarily limited to early-mid 20^{th} scientists including R. C. King and M. Demerec. Therefore understanding of internal anatomy of SWD and skill in micro-dissection was painstakingly acquired through hands-on experience. Approximately 200 spotted wing drosophila, from trap samples, representing 3 localities (two in Washington state and a localized cluster in British Columbia, Canada) and every month of the year, were dissected to determine their reproductive condition. Select specimens were slide mounted in Hoyer's medium and further studied using light microscopy (phase contrast and dark field) at magnifications from 200x -100x. Photographs were made using a Canon EOS 7D and microscope adapter. Female reproductive condition was categorized as follows:

1. No distinguishable ovarioles.
2. With distinguishable ovarioles.
3. Eggs large but no filaments.
4. Mature eggs with filaments.
5. Ovaries with few mature eggs often wrinkled, without developing eggs.

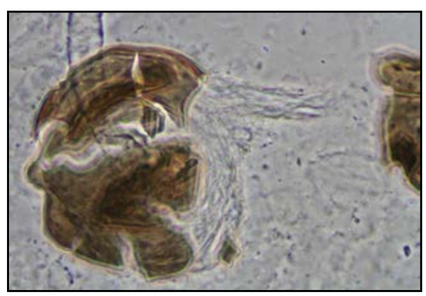


Fig. 1. A toroidal mass of sperm evident in spermathecal squash from 20-28 Oct, BC, Canada.

Observations thus far include:

- Presence of spotted wing drosophila in the field did not always coincide with egg-laying capacity.
- Viable eggs were found in dissected female SWD from mid-May-Oct (Figs. 2-3).
- Wrinkled eggs (non-viable) were found in dissected females from May and Sep (Fig. 3).

- Overwintering flies-mix of different ages.
- Some overwintering females were mated (spermatozoa observed in spermathecae or seminal vesicle) (Fig 1).
- Some overwintering females (Nov-April) severely starved-remaining eggs incorporated into a thin fat layer lining a hollow abdomen.

Variation in SWD activity and economic damage in 2012 was reported in west coast states from California and Oregon and southern Washington which experienced high SWD pressure, to northwestern Washington where economic damage from SWD was not reported until the end of the red raspberry season. SWD clinal variation occurs along the west coast, therefore seasonality of some but not all of the observations mentioned above may vary according to location.

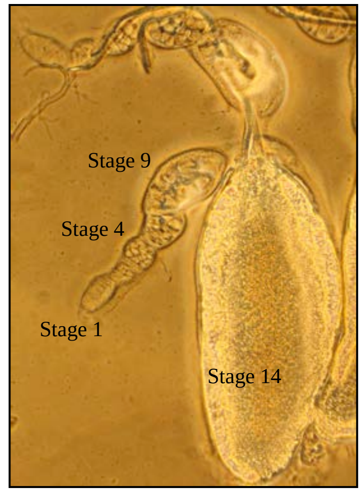


Fig. 2. Ovariole from a 15-18 day NWREC culture SWD shows a mature egg (stage 14) ready for oviposition with eggs representing stages 9, 4 and 1 seen advancing in another ovariole (behind) within the same ovary.

Fig. 3. A mix of both viable and older eggs can be seen in this 13-20 Sep SWD from BC, Canada. Viable eggs were observed in dissected SWD from mid-May through September. Older eggs were observed from late May - early June and again in September.

Publications:

Gerdeman, B S., L. K. Tanigoshi and G. Hollis Spitler. 2011. Spotted wing drosophila (SWD) monitoring, identifying, and fruit sampling. WSU Ext. Fact Sheet FS049E, pp. 3.

Gerdeman, B. S. and L. K. Tanigoshi. 2011. Biology and management of spotted wing drosophila, *Drosophila suzukii* (Matsumura) in small fruits in the Pacific Northwest. IOBC/wprs Bull. 70: 129-136.

Bruck, D. J. M. Bolda, L. Tanigoshi, J. Klick, J. Kleiber, J. DeFrancesco, B. Gerdeman and H. Spitler. 2011. Pest Management Sci. 67: 1375-1385.

Project No.: New

Title: Management impacts of a unilateral insecticide tactic to control spotted wing drosophila, *Drosophila suzukii* (Matsumura) and the resurgence of economic populations of spider mites and affects on their phytoseiids mite predators

Year Initiated: 2013 **Current Year:** 2012 **Terminating Year:** 2015

Personnel: **Lynell K. Tanigoshi**, Entomologist
Beverly S. Gerdeman, Research Associate, Entomology
G. Hollis Spitler, Agricultural Research Technician
WSU Mount Vernon Northwestern Washington Research & Extension Center

Funding: $9,921

Justification and Background: Spotted wing drosophila, *Drosophila suzukii* (Matsumura), SWD, is a direct pest of red raspberry, promoting premature softening and bacterial contamination, which results in rapid decay. Chemical controls for SWD in northwestern Washington red raspberry still remain unclear since the recent invasion of the pest in late season 2009. A list of effective chemicals has been recommended. Questions still remain about the concept of preventative contact control of adults in terms of rotating effective products of to prevent or delay SWD's ability to develop resistance to a whole group of products (e.g., pyrethroids). Grower IPM programs are now dominated by industry's zero tolerance for SWD. This concern has regressed to a seven-day rotation program to control SWD while covering other pests that were on a spray as monitoring indicated. This calendar spray schedule for SWD, MRLs, PHIs and zero tolerance by processors has seen the resurgence of two spotted mite, *Tetranychus urticae* Koch and yellow spider mites, Eotetranychus carpini borealis (Ewing). Because Mustang Max is inexpensive, its MRLs to Asia, short PHI and REI, number of applications per season, failure to rotate with non-pyrethroids, could result in cross resistance to other Group 3 insecticides. The phenomenon for inducing spider mite resistance has long been known for pyrethroids from the tree fruit and strawberry literature. Insect resistance management principles will require spider mite monitoring, precision applications of registered acaricides, labeling of new chemistries for caneberries, in addition to better rotation of pyrethroids and intervals between insecticide applications. More precise information on first SWD adult emergence, their population dynamics and phenology with fruit ripeness, fecundity and oviposition periods need to be integrated with their impacts on the secondary pests of caneberries which were integratively managed before the invasion of SWD. This knowledge will provide raspberry growers with making better decisions for optimum timing of protective cover sprays while accounting for picking schedules and targeted markets like Korea, Canada and Mexico. The $44.3 million dollar (20011 USDA NASS) red raspberry industry in Washington State could suffer severe economic losses in 2013 given a more normal season compared with 2012.

Relationship to WRRC Research priority(s): #1 priority – *Evaluation of the life cycle and management options of the Spotted Wing Drosophila*.

Objectives:

1. Continue evaluating insecticide contact toxicity and field-aged residual efficacy of labeled and experimental insecticides that may result in labeling for red raspberry.

2. Monitor commercial fields for spider mite outbreaks that may be associated with intense spray programs associated with the need to protect ripening berries from SWD oviposition.

3. Develop usage guidelines for those registered insecticides effective in controlling SWD in red raspberry that will assist Washington growers meet MRL requirements for the major export countries of Canada, Mexico, Japan, South Korea and Taiwan.

Lab bioassays. Insecticide contact toxicity will determined by directly spraying adult SWD with a Precision Potter Spray Tower at the high field rate for each product in an equivalent of 100 gal/acre. Water will serve as an untreated control in all bioassays. Adults will be anesthetized with a portable CO_2 dispenser, placed on a disposable 100 x 15 mmm Petri dish top or bottom in the spray tower and sprayed directly with 2 ml of the insecticide. Immediately after treatment, 5 flies will be placed into untreated Petri plates with a small piece of meridic diet (~15 mm^3), half section of a moisten cotton dental wick and covered with the Petri plate lid. Dishes will be held at lab temperature and humidity under constant light. Mortality will be evaluated after 24 hours. Each treatment will be repeated once for a total of eight replicates. An arsine transformation of the percentage adult mortality will be performed to stabilize variance. Effects of treatments on adult mortality will be determined with a one-way analysis of variance (ANOVA) followed by means separation using Fisher's least significant difference (LSD) test (P=0.05). Reported means will be back-transformed to percentages for presentation.

Field efficacy trials. Applications will be applied with a Spray Systems® CO_2 backpack sprayer equipped with a 36 inch boom with 4 TeeJet® 8002VS flat fan nozzle spaced at 12 inches. This unit will deliver 96 gal/acre to run off at 40 psi. All applications will include the adjuvant MSO at 0.0025 v/v. Treatment applications will be applied in a 3' x 9' swath at chest height on the westide of each unreplicated 10'x9' plot. Posttreatment evaluations will be made by sampling 4 random, mature primocane leaflets per plot within the spray swath. Each leaflet will be placed top side up in a standard disposable Petri dish with a moisten cotton dental wick, 5 mm^3 piece of diet and 5 SWD adults reared from our lab colony. These replicated treatment units will be evaluated for adult mortality after 24 hours. The leaf cohorts will be collected daily out to 8 days for the multiple treatments, exposed to new SWD adults until <50% mortality occurred for respective treatments. These data will provide adult SWD mortality responses to field aged, contact/ingestion residues for field rates of registered and experimental/unlabeled insecticides. Percent adult mortality will be subjected to arcsine transformation prior to analysis. Effects of treatments on adult mortality will be determined with one-way ANOVA followed by means separation using Fisher's least significant difference (LSD) test (P = 0.05). Reported means will be back-transformed to percentages for presentation.

Spider mite population resurgence within a SWD dominated management program. We will monitor at weekly intervals, from April through the harvest period, two major red raspberry growers in the Lynden area that have report early season levels of two spotted spider mites (TSSM), *Tetranychus urticae and* yellow spider mite (YSM), *Eotetranychus carpini borealis* over the past two seasons. With grower/fieldman cooperation, we will take samples at appropriate REIs for every insecticide/miticide applied for mite control and during the harvest period for SWD management. Motile life stage counts will be made by randomly collecting 25 terminal leaflets from foliage at chest height from both sides of the row and brushing them with a mite-brushing machine onto glass plates coated with a thin film of dishing washing detergent on the same day. Five plots, 10x30 feet will be randomly placed in each red raspberry field. Counts will be made with a 10X stereomicroscope. Motile stages of phytoseiid predators (e.g., *Neoseiulus fallacis*) will also be sampled from the same glass plate. Small plot trials will be conducted at the WSU NWREC 'Meeker' field to evaluate field efficacy of experimental acaricides for submission to IR-4 for residue trials.

MRL guidelines

Countries have responded to increasing global trade and heightened food safety concerns, by setting maximum residue levels (MRL) on agricultural imports, often stricter than our own. Spotted wing drosophila has disrupted red raspberry production in Washington State. The industry has responded to its first direct pest by setting a zero tolerance toward larvae contaminating the fruit, resulting in growers applying up to 10 chemical treatments at 5-7 day intervals until the end of the harvest season. Spotted wing drosophila has nearly replaced our decades' long emphasis on promoting IPM, with calendar sprays. Growers have not only increased insecticide use to control of SWD but also often severely restricted their choice of effective chemistries in order to meet their target export market's approved list. IRM management strategies have increasingly been replaced with multiple back-to-back applications of the same mode of action chemistries, such as Mustang Max®. While Mustang Max like other pyrethroids provides excellent control, resistance development is eminent.

We will provide Washington red raspberry growers with examples of insecticide usage plans (i.e. rates and number of applications/season) from the five major export countries. Following these guidelines will assist our growers to meet their target MRLs. These guidelines fluctuate periodically requiring annual reevaluation to remain current. We propose to interface with a similar database already managed by Dr. Michael J. Willett, Technical Issues Manager for the Northwest Horticultural Council. With this information, growers will be more confident to increase their mode of action chemistries fending off resistance.

Anticipated benefits and information transfer: This study will provide a list of registered insecticides, including new MOA chemistries, to manage SWD in red raspberry in Washington with emphasis on IRM, implications of foreign market MRLs and new IR-4 residue tolerance projects. New knowledge about the timing of chemical applications, phenology of red raspberry ripening characteristics, pest emergence such as early season spider mites, SWD generations, population dynamics and ovarian morphology will provide directions for identifying optimum window(s) to effectively manage SWD. Hopefully we can provide growers with easily accessible MRLs for their export countries of choice. Extension education will provide this information to all interested growers through meetings, internet resources and websites.

Budget:

	2013
00 Salaries[1]	$4,404
01 Wages[2]	$2,000
03 Operations (goods and services[3])	$1,000
04 Travel[4]	$500
07 Employee benefits[5]	$2,017
Total	**$9,921**

Benefit details:

[1/]Research Associate in Entomology ($4,404).
[2/]NWREC time-slip employee ($2,000).
[3]/Field and lab trial supplies, field maintenance at WSU NWREC.
[4/]Vehicle maintenance and fuel for off-station travel to field sites.
[5/]Research Associate @ 38.12% ($1,679), time slip employee 16.9% ($338).

Application Date: November 13, 2012

Name of Applicant Organization/Company:
USDA-ARS Horticultural Crops Research Laboratory
3420 NW Orchard Ave.
Corvallis, OR 97330

Principal Investigator:
Jerry Weiland
Research Plant Pathologist
(541) 738-4062
jerry.weiland@ars.usda.gov

Co-PI and/or cooperator:
Chris Benedict (Co-PI)
Regional Extension Specialist
Washington State University Extension
1000 N. Forest St., Suite 201
Bellingham, WA 98225
(360) 676-6736 ext. 21
chrisbenedict@wsu.edu

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

Year Initiated 2013 Current Year 2012 Terminating Year 2014

Funding:
Total amount requested: $13,582 (2013); $13,582 (2014); $27,164 (2013-2014).
Other sources of funding: We will solicit funding from the British Columbia Raspberry Industry Development Council and the Oregon Raspberry and Blackberry Commission for similar surveys.
Current funding already received for this project: None

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

Year Initiated___2013___ Current Year____2012____ Terminating Year___2014___

Project Description and Expected Outcomes:
Verticillium dahliae was recently isolated from wilted and dying red raspberry plants found in several western Washington production fields. We propose to survey for the incidence of *V. dahliae* in production fields to determine if the pathogen is widespread in the red raspberry industry and to determine if the pathogen is consistently associated with fields containing wilting and dying plants. Our survey will utilize two common methods for *V. dahliae* detection, a culture-based method and a DNA-based method, to ensure robust detection and to compare methods for detection and quantification of the pathogen. We expect to determine the incidence of *V. dahliae* in red raspberry production fields and establish whether grower observations of cane wilting and death are associated with this pathogen. We also expect to determine which method of pathogen detection is more effective at detection and quantification of *V. dahliae* in field soils and plant samples. This research directly addresses a #1 priority of the Washington Red Raspberry commission, understanding soilborne pathogens and their effects on plant health.

Justification and Background:
Verticillium dahliae is a common soilborne pathogen in many agricultural soils and has recently been suspected of infecting and killing red raspberry plants in the state of Washington. Historically, relatively little research has addressed the role of *V. dahliae* in red raspberry production. An early report indicated that *V. dahliae* killed canes and reduced yields of *Rubus idaeus* cultivars in England (Harris, 1925). The pathogen was also described from Ontario, Canada, where 5 - 20% of the plants in red raspberry fields were infected (Berkeley and Jackson, 1926). Symptoms of the disease have been described as yellowing and wilting leaves followed by cane death. Occasionally, a blue discoloration was observed on canes, but this was not found consistently in all infected plants. Often, the plants were not completely killed and new shoots were able to grow from noninfected roots. But, in other cases, entire hills of red raspberry were killed. The disease usually has a patchy distribution and severity may differ from year to year; fields of Cuthbert that had severe Verticillium wilt one year only had a trace of disease in the following two years (Berkeley and Jackson, 1926).

Red raspberry cultivars are often considered as resistant to *Verticillium* (Fiola and Swartz, 1994). However, *V. dahliae* was recently found in plant and soil samples collected from declining red raspberry fields in western Washington in 2012 by two commercial analytical laboratories and one research laboratory (Weiland, unpublished data). In addition, two years of greenhouse inoculations of Meeker red raspberry with *V. dahliae* have shown that this cultivar can be infected and killed by the pathogen (Figure 1).

Although the pathogen has been detected from naturally-infected plants and it is known to cause disease, additional information is needed in order to establish whether *V. dahliae* is a threat to red raspberry production. First, the incidence of *V. dahliae* in production fields as well as the amount of inoculum associated with disease remains unknown. A survey is needed in order to determine: a) whether *V. dahliae* is widely present in the red raspberry industry; b) if its presence is associated with the pockets of disease observed in fields in 2012; and c) to determine if particular inoculum levels are associated with disease. Second, results from each of the three laboratories were somewhat contradictory in terms of the presence and quantity of *V. dahliae* in plant and soil samples. It is unclear whether these difference were due to the variability inherent in sampling (e.g., some samples had *V. dahliae* and some samples did not) or whether the differences were due to the method of detection. Two methods were used by the laboratories for the detection of *V. dahliae*: A culture-based method and a DNA-based method. The culture-based method relies on identification of living cultures of *V. dahliae* from soil and plant samples whereas the DNA-based method is based on the selective detection of *V. dahliae* DNA. Both methods have advantages and disadvantages, but a comparison should be made to determine which method is the most sensitive at detection and which method is the best at quantification of pathogen inoculum levels.

Relationship to WRRC Research priority(s):
This proposed research directly addresses a #1 priority of the WRRC, understanding soilborne pathogens and their effects on plant health.

Objectives:

1. Determine the incidence of *V. dahliae* in red raspberry production fields;
2. Determine if the presence of *V. dahliae* in soil and plant samples is associated with disease symptoms of wilting and cane death;
3. Determine which inoculum levels are associated with disease symptoms;
4. Compare culture-based and DNA-based methods for effectiveness of *V. dahliae* detection and quantification.

Procedures:
Over a two-year period we propose to evaluate the incidence and quantity of *V. dahliae* in red raspberry production fields using two available methods for detection and quantification. We will reapply for funding next year to complete the second year of the survey. In each year for two consecutive years (2013-2014), 25 diseased sites and 10 nondiseased sites in red raspberry production fields will be identified and sampled for the presence of *V. dahliae*. Sampling will begin in late June or as soon as symptoms associated with Verticillium wilt are discovered. Diseased sites are defined as areas within the production field where symptoms of wilting, cane dieback, sparse canopy, stunted growth, and/or blue stem discoloration are observed. Within each diseased site, five symptomatic plants within a single row, and within 1-3 plants from each other will be sampled for *V. dahliae* infection by collecting 2-3 symptomatic canes/plant. Soil cores (12”) will also be collected immediately adjacent to each symptomatic plant (within hill) and then bulked for each disease site. For nondiseased sites, canes from five healthy plants and adjacent soil cores will be collected as described above. Nondiseased sites are defined as apparently healthy areas within the production field where no Verticillium wilt symptoms are observed and plants have normal coloration and robust growth.

Two methods will be used to detect and quantify the pathogen from soil and plant samples. Each plant and soil sample will be divided into two samples with one half of each sample to be tested by the culture-based method and the other half of each sample to be tested by the DNA-based method. The culture-based method has been widely used to detect and quantify *V. dahliae* by research and diagnostic labs for decades (Butterfield and DeVay, 1977), whereas the DNA-based methods are more recent (Bilodeau et al., 2012, Duressa et al., 2012, Markakis et al., 2009). For the culture-based method, plant samples are surface-disinfested with a 10% bleach solution, cut into segments, and then plated into petri dishes containing a semi-selective medium from which diagnostic *V. dahliae* cultures will grow if the pathogen is present. Soil samples will be dried for 2 weeks to eliminate competing contaminant fungi and then spread on the same semi-selective medium used above. For the DNA-based method, *V. dahliae* DNA will be extracted and amplified from plants and soil samples using established protocols (Bilodeau et al., 2012, Duressa et al., 2012, Markakis et al., 2009).

Pathogen incidence for each site (diseased and nondiseased) will be determined by the presence or absence of *V. dahliae* as detected by each method. Quantification of the pathogen from plant samples will be based on the number of plants from which the pathogen was detected by each method. Quantification of the pathogen from soil will be based on the number of *V. dahliae* cultures that grow from each soil sample or the amount of *V. dahliae* DNA amplified by the DNA-based method. Data will be compiled and results from both diseased and nondiseased sites will be compared to determine the incidence of *V. dahliae* in red raspberry production fields (Objective 1). Results from plant and soil samples at diseased sites will be used to determine if the presence of *V. dahliae* in the soil is associated with disease (Objective 2) and to determine which inoculum levels are associated with disease symptoms (Objective 3). Finally, results from each method will be compared to determine which method is best at detecting and at quantifying *V. dahliae* from plant and soil samples (Objective 4). Incidence data will be analyzed using the chi-square test for independence and quantity data will be analyzed using ANOVA.

Timeline:

Activity	**2013**	**2014**
Plant and soil sample collection	June-October	June-October
Plant and soil sample processing	June-December	June-December

Anticipated Benefits and Information Transfer:

This research will identify if *V. dahliae* is widely prevalent and causing disease in Washington red raspberry production fields. It will also identify inoculum levels that are associated with disease and identify appropriate methods for *V. dahliae* detection and quantification. Results will lay the foundation for future research including disease screen assays for resistance among red raspberry cultivars and the evaluation of production (e.g. fertilization, irrigation, etc.) and disease management practices (fumigant rates, chemistries, etc.) for their effects on inoculum levels and disease development. Findings will also help growers interpret results from diagnostic laboratories. Our 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:
Berkeley, G. H. and Jackson, A. B. 1926. Verticillium wilt of the red raspberry. Scientific Agriculture 6: 261-270.
Bilodeau, G. J., Koike, S. T., Uribe, P., and Martin, F. N. 2012. Development of an assay for rapid detection and quantification of *Verticillium dahliae* in soil. Phytopathology 102: 331-343.
Butterfield, E. J. and DeVay, J. E. 1977. Reassessment of soil assays for *Verticillium dahliae*. Phytopathology 67: 1073-1078.
Duressa, D., Rauscher, G., Koike, S., Mou, B., Hayes, R. J., Subbarao, K. V., and Klosterman, S. J. 2012. A real-time PCR assay for detection and quantification of Verticillium dahliae in spinach seed. Phytopathology 102: 443-451.
Fiola, J. A. and Swartz, H. J. 1994. Inheritance of tolerance to *Verticillium albo-atrum* in raspberry. HortScience 29: 1071-1073.
Harris, R. V. 1925. The blue stripe wilt of the raspberry. The Journal of Pomology and Horticultural Science 4: 221-229.
Markakis, E. A., Tjamos, S. E., Antoniou, P. P., Paplomatas, E. J., and Tjamos, E. C. 2009. Symptom development, pathogen isolation and real-time qpcr quantification as factors for evaluating the resistance of olive cultivars to *Verticillium* pathotypes. European Journal of Plant Pathology 124: 603-611.

Figure 1. Increasing severity of verticillium wilt symptoms (from left to right) on inoculated plants of 'Meeker' red raspberry in a 2012 greenhouse disease assay. A) healthy, noninoculated control plant. B) less vigorous growth of inoculated plant. C-E) stunted growth, wilting, cane death, and leaf yellowing on inoculated plants. F) entire plant died as a result of inoculation. Picture was taken two months after inoculation with *V. dahliae*.

Budget:

	2013	2014
Salaries[1/]: Lab Technician	$1630	$1630
Salaries[2/]: Sample collection	$1175	$1175
Shipping[3/]: Samples	$160	$160
Culture-based sample processing	$1000	$1000
DNA-based sample processing	$6000	$6000
Misc sampling supplies[4/]	$200	$200
Travel[5/]	$2430	$2430
Meetings	$200	$200
Benefits[6/]	$787	$787
Total	**$13,582**	**$13,582**

Budget Details

[1/] One USDA Laboratory Technician at 0.05% FTE.

[2/] One WSU Whatcom County Extension Personnel at 0.03% FTE.

[3/] Shipping samples from Bellingham, WA to Corvallis, OR for processing.

[4/] Sampling bags (500 @ $0.40 = $200).

[5/] Travel to and from research sites, 3000 miles at $0.51/mile ($1530) for WSU Extension Personnel. Weiland will travel to Washington three times a year to assist in surveying, sample collection, and to present research findings at the Small Fruit Conference ($900).

[6/] Benefits USDA laboratory technician (16.6% = $271) and WSU Extension Personnel (43.9% = $516)

2013 WASHINGTON RED RASPBERRY COMMISSION RESEARCH PROPOSAL

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

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

PI: Inga Zasada
Organization: USDA-ARS Horticultural Crops Research Laboratory
Title: Research Plant Pathologist
Phone: (541)738-4051
Email: inga.zasada@ars.usda.gov
Address: 3420 NW Orchard Ave.
City/State/Zip: Corvallis, OR 97330

Co-PI: Thomas Walters
Organization: WSU-Mount Vernon NWREC
Title: Assistant Horticulturalist
Phone: (360)848-6124
Email: twwalters@wsu.edu
Address: 16650 State Route 536
City/State/Zip: Mount Vernon, WA 98273

Cooperator: Norm McKinley, Dupont

Year Initiated___2013___ **Current Year**____2012____ **Terminating Year**___2014___

Other sources of funding: Dupont funded the 2012 Vydate trail described in the Justification and Background section of this proposal - $5,840.
Agency Name: None
Amt. Requested/Awarded: None
Notes: None

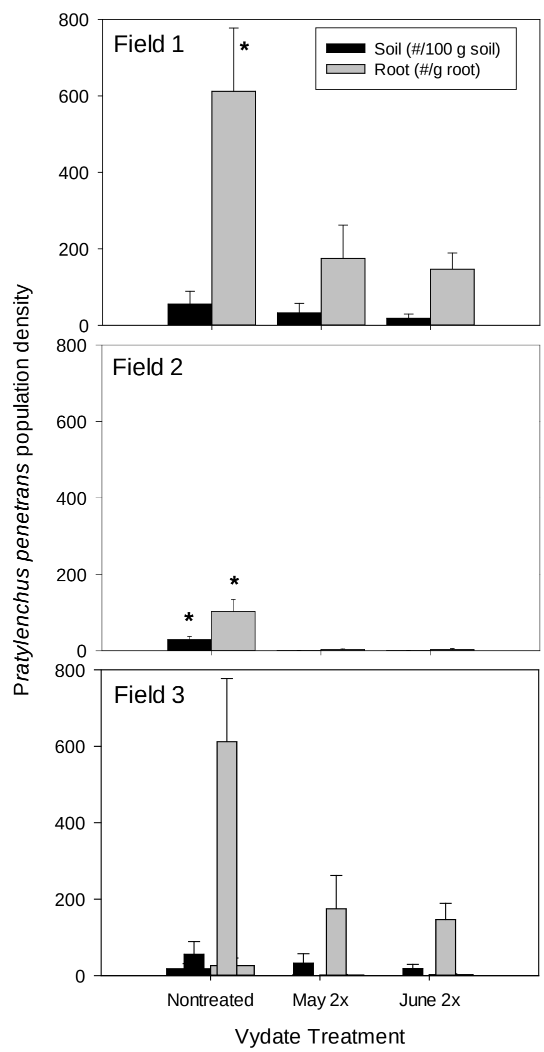
Description:
Recently, Vydate (oxamyl) was registered for use on non-bearing raspberry for the control of plant-parasitic nematodes in Washington, specifically the root lesion nematode, *Pratylenchus penetrans*. This means that Vydate can be applied to red raspberry at least 12 months prior to a harvest (EPA SLN No. WA-120005). This is an important addition to the raspberry growers' nematode management toolbox, and being able to maximize the efficacy of this product should provide growers with another way to control nematodes. *Pratylenchus penetrans* attacks the roots of raspberry and slowly causes feeder roots to die, limiting the capacity of the plant to uptake water and nutrients resulting in decline. If *P. penetrans* is not managed it can result in the reduced lifespan of a raspberry planting. We propose to conduct on-farm field trials to determine the best time in the spring after planting to apply Vydate to maximize nematode control. This

research directly addresses a #1 priority of the Washington Red Raspberry commission, soil fumigant techniques and alternatives.

Justification and Background:

Root lesion nematodes, *Pratylenchus penetrans*, are migratory endoparasites, migrating between the soil and roots. This nematode is prominent in western Washington soils and has been shown to reduce raspberry vigor and yield (Gigot et al., accepted; Zasada and Walters, unpublished data). Currently, *P. penetrans* is managed in red raspberry by pre-plant fumigation with Telone C-35; there are few reliable post-plant nematicides registered for use in raspberry. We previously evaluated 13 post-plant nematicides for ability to suppress *P. penetrans* in raspberry (Zasada et al., 2010). Of the tested products only Vydate (oxamyl) and fosthiazate suppressed this nematode on raspberry plants. It is unlikely that fosthiazate will be labeled for us on red raspberry. However, Vydate was recently labeled for us on non-bearing raspberry for the control of nematodes in Washington (EPA SLN NO. WA-120005). This is a different type of use compared to that in Canada where Vydate is labeled for use on bearing plants; therefore it is essential that we identify the optimal way to apply Vydate to maximize nematode control.

Figure 1. Population densities of *Pratylenchus penetrans* in plots treated with Vydate in spring 2012.



In 2012, we conducted on-farm trials with the goal of evaluating the phytotoxicity of Vydate to raspberry. Vydate was applied to either newly planted tissue cultured or dormant cane plants twice in May or June. Phytotoxicity was evaluated and soil samples were collected before treatment and soil and root samples collected in the fall for quantification of *P. penetrans* populations. Initially, there were very few nematodes detected in these fields with average populations of 0, 3, and 1 *P. penetrans*/100 g soil in Fields 1, 2, and 3, respectively. In the fall *P. penetrans* population densities in roots were significantly higher (indicated by * in **Figure 1**) in nontreated plots compared to Vydate-treated plots. The same trend was observed in Field 3, however it was not statistically significant. Vydate was not phytotoxic to raspberry in these trials.

These results are significant because they demonstrate that Vydate will be a very important nematode management tool for Washington raspberry growers. Currently the only application timing recommendation for Vydate is that soil temperature be at least 45 °F at a depth of 8 inches. The Vydate technical bulletin states “For perennial crops, the period of root growth is critical. Applications should be timed to coincide with periods of root flush or growth”. Nematode control by Vydate in relationship to root growth in northern Washington needs to be considered to maximize the efficacy of this product.

Relationship to WRRC Research priority(s):
This proposed research directly addresses a #1 priority of the WRRC, soil fumigant techniques and alternatives.

Objectives:
1. Optimize the use of Vydate for nematode suppression in non-bearing raspberry, and;
2. Continue to monitor nematode population dynamics in raspberry plants treated with Vydate in 2012.

Procedures:
Over a two-year period we propose to evaluate Vydate for the control of *P. penetrans* in non-bearing raspberry. All trials will be conducted in grower fields.

For **Obj. 1** we will establish trials in three newly planted and fumigated raspberry fields in northern Washington in spring 2013. Each of these fields will represent a different variety. In each field, a randomized block design experiment with four replications of each treatment will be established (48 plots total). The treatments along with the justification for each treatment will be:

1. **Nontreated control**
2. **April Vydate 2x –** Vydate will be applied at 2 pints/acre twice in April; applications will be separated by 3 weeks. Due to reliable rainfall in April this is a very practical time of year since the application will not need to be watered in if applied prior to a rain. This treatment was not evaluated in 2012 trials.
3. **May Vydate 2x –** Same 2x rate as for April. Soil temperatures will be warmer in May and nematodes may be more active and root growth more abundant making this a better time to apply Vydate.
4. **June Vydate 2x –** Same 2x rate as for April. Soil temperatures will be even warmer than in May, however, rainfall will not be as reliable as in April/May making it necessary to follow the application with 0.25 or 0.50 acre inch of water.

Plots will be approximately 30 ft long consist of 12 dormant canes or tissue cultured raspberry plants. Six soil cores will be collected from each subplot prior to the first April treatment, combined and nematodes extracted and quantified. At this time soil temperature probes will be placed at each location. Vydate will be applied to plots as described above. Plant growth (cane height and number of canes) will be evaluated in July. Soil and root samples will be collected again in the fall from plots. Roots will be separated from soil and nematodes will be extracted from roots and soil and quantified. *Pratylenchus penetrans* populations will continue to be followed in these trials in spring and fall 2014, as described above.

For **Objective 2** we will return to the trials established in 2012 and sample soil and roots for *P. penetrans* in spring and fall 2013 to see how long Vydate protects new plants from nematodes.

We will also continue to monitor plant performance as described above. Analysis of Variance will be used to identify treatment differences within a location and year.

Timeline:

Activity	**2013**	**2014**
Sample 2012 trials for nematodes	April, Sept	
Sample 2013 trials for nematodes	April, Sept	April, Sept
Apply 2013 Vydate applications	April, May, June	
Evaluate 2012 trials for phytotoxicity	July	
Evaluate 2013 trials for phytotoxicity	July	July

Anticipated Benefits and Information Transfer:
This research will provide raspberry growers with information to maximize the efficacy of non-bearing applications of Vydate for *P. penetrans* control. Our research will also provide information about potential phytotoxic side effects of Vydate to newly planted raspberry. Two applications of Vydate at 2 quarts/acre will cost a grower approximately $150/acre (chemical plus labor); our research will ensure that this is money well spent. Our research results will be presented to red raspberry growers at meetings (Berry Workshop, Lynden) and the annual WSU-NWREC field day. Results will also be communicated to the Washington Red Raspberry Commission and to Peerbolt Crop Management for inclusion in their newsletters.

References:

Gigot, J., Walters, T.W., and Zasada, I.A. Impact and Occurrence of *Phytophthora rubi* and *Pratylenchus penetrans* in commercial red raspberry (*Rubus idaeus*) fields in northwestern Washington. International Journal of Fruit Science (submitted).

Zasada, I.A., Walters, T.W., and Pinkerton, J.N. 2010. Post-plant nematicides for the control of root lesion nematode in red raspberry. HortTechnology 20:856-862.

Budget:

	2013	2014
Salaries	$0	$0
Administrative Professional[1/]	$2,040	$1,020
Time-Slip[2/]	$780	$450
Operations (goods & services) [3/]	$5,760	$3,840
Travel[4/]	$1,000	$500
Other	$0	$0
Equipment	$0	$0
Benefits[5/]	$867	$464
Total	**$10,447**	**$6,274**

Budget Details

[1/]Tom Walters will be responsible for the day-to-day management of this research.

[2/]An additional person will be hired to help with nematode sampling and nematicides applications.

[3/]A total of 288 soil/root samples and 192 soil/root samples will be collected in 2013 and 2014, respectively. Cost of processing a single sample is $20.

[4/] 2012 (Walters 9 trips, Mt. Vernon - Lynden); 2013 (Walters 3 trips, Mt. Vernon - Lynden). Zasada will travel to Washington once a year to present research findings to the commission and at the WSU Small Fruits Workshop.

[5/] Benefits Tom Walters – 30% and 31% in 2013 and 2014, respectively; helper – 31% in both years.