WASHINGTON STATE UNIVERSITY

2009 Raspberry Research Proposals
2008 Progress Reports

to the Washington State Raspberry Commission

Washington Red Raspberry Commission
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Commission	Meetings (2008)	
WA Red Raspberry Comm.	July 10	Ag Canada Field Day
	July 15	EQIP Deadline
	July 23	Machine Harvest Trial *(Randy Honcoop Farm)*
	July 28, 29	Conference *(Tri-Cities, WA)*
	Sept 10	WRRC Board Meeting *(Mt. Vernon, WA)*
	Oct 29	WRRC Board Meeting *(Lynden, WA)*
	Dec 4	Small Fruit Center Conference *(Covallis, OR)*
	Dec 8, 9	N. American Berry Conference *(Grand Rapids, MI)*
	Dec 15-17	WSU Small Fruit Workshop *(Lynden, WA)*

Washington Red Raspberry Commission

Production Research Priorities
(2009)

#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. (moved from #2)
- Harvest contaminants and problems stemming from the loss of longstanding insecticides and nematacides.

#2 Priorities

- Product and Production Certification Systems - food safety & security, standards, traceability.
- Weed management
- Nutrient/Irrigation management.
- Viruses/crumbly fruit. (moved from #1)
- Mite management (moved from #3)

#3 Priorities

- Nutraceutical/Nutritional benefits for product development.
- Season extension: improve viability of fresh marketing.
- Labor saving cultural practices including mechanical pruning and tying techniques. (moved from #2)
- Foliar & Cane Diseases – i.e. spur blight, yellow rust, cane blight, etc. (replaced Yellow Rust)
- Vertebrate pest management (added)

Post Harvest and Product Development Research Priorities
(2009)

#1 Priorities

- Explore new technologies to enhance shelf life and convenience (without sacrificing nutrition benefits)
- Coating to reduce raspberry bleeding in bakery products
- Understand the effects of freezing and processing on nutraceutical properties
- New product development in dried fruit

Summary
Budget Requests

LAST YEAR FUNDING REQUESTS (2008)

Ongoing Projects (2008)

Project No.	*Short Title*	*Lead Scientist*	*Amount Requested*
13C-3755-5641	Red Raspberry Breeding	Moore	$30,500
Development of Value-Added Dried Raspberry		Clary	$20,415
13C-3543-4370	Insect/Mite Management	Tanigoshi	$12,762
Red Raspberry Cultivar Development		Kempler	$ 6,900
13C-3419-7297	Postemergence Canada Thistle	Miller	$ 3,770
Effects of Drip Tape Placement		Walters	$ 5,913
Irrigation Deficits		Walters	$ 9,437

CURRENT YEAR FUNDING REQUESTS (2009)

Project No.	*Short Title*	*Lead Scientist*	*Amount Requested*
13C-3755-5641	Red Raspberry Breeding	Moore	$45,000
13C-3755-3641	Machine Harvesting	Moore	$ 6,842
13C-3419-7297	Postgemergence Canada Thistle	Miller	$ 3,932
13C-3543-4370	Integrating Insect Management	Tanigoshi	$ 9,060
Red Raspberry Cultivar Development		Kempler	$ 7,000

NEW PROJECTS (2009)

Short Title	*Lead Scientist*	*Amount Requested*
Efficacy of a Phosphite	Walters	$ 6,150
Cooperative Raspberry Cultivar	Finn	$ 7,500
Identifying Root Traits	Bryla	$12,604

TABLE OF CONTENTS

Project: 13C-3755-5641
Title: Red Raspberry Breeding, Genetics and Clone Evaluation
Personnel: Patrick P. Moore, Professor, WSU Puyallup
Wendy Hoashi-Erhardt, Scientific Assistant, WSU Puyallup
Reporting Period: 2008

Accomplishments: Seventy-eight crosses were made in 2008, with 76 of the crosses for cultivar development and two crosses for germplasm purposes. Emphasis was placed on using parents with root rot tolerance, RBDV resistance or that machine harvest well. Approximately 5,000 seedlings were planted at WSU Puyallup in 2008. These will be evaluated in 2010 and 2011. An additional 2,100 seedlings from 30 crosses were planted at Sakuma Bros for evaluation for machine harvestability.

The planting of 9,800 seedlings established in 2005 was evaluated in 2007 and 71 selections were made and 24 additional selections were made in 2008. The planting of 9,500 seedlings established in 2006 was evaluated in 2008 and 81 selections made (0.85%). The seedlings in the 2006 planting were the result of crosses made in 2005, when the first selections that had been evaluated for machine harvestability were used as parents. Use of these parents has had an impact on the seedling population. Many of the seedlings in certain crosses have very easy fruit removal. **WSU 1499**, **WSU 1471** and **WSU 1507** were the parents most represented among the seedlings selected. 9.4% of the seedlings from the cross of **WSU 1499** x **WSU 1507** were selected, 5.6% of the cross of **WSU 1499** x **WSU 1471** and 4.8% of the cross of **WSU 1499** x **WSU 1539**. The evaluation process will be accelerated for some of the most promising 2008 selections. They will be propagated for planting in the machine harvesting trial, replicated plots at Puyallup and root rot plots in 2009.

The replicated planting at Puyallup established in 2005 was harvested in 2007 and 2008 (Table 1). Performance of **WSU 1499** has not been as good as expected, possibly a result of spur blight. The fruit size was much less than **Meeker** or **Willamette**. Fungicide sprays for spur blight were applied in 2008 and these plots will be harvested in 2009.

A new machine harvesting trial was planted at Burlington, WA. One hundred raspberry clones were included in the new planting, with 81 WSU selections, 16 BC selections and 3 cultivars. The machine harvesting trials planted in 2005 and 2006 in Lynden were harvested in 2008. There were 6 selections in the 2005 planting that appeared to harvest well in 2007. The same selections harvested well in 2008, but some of them had low yield estimates. One selection appeared to perform much better in 2008 than in 2007 and will be evaluated further. There were 12 selections in the 2006 planting that harvested well in 2008, three that had been evaluated in previous plantings and nine that were evaluated for the first time in 2008. Several of these selections had large fruit that harvested very easily with high yields.

Fruit samples of 17 WSU selections, 1 BC selection and 3 cultivars were collected from the machine harvest plots and total anthocyanins, soluble solids, pH and titratable acidity measured (Table 2). Four selections had total anthocyanin content similar or greater than for **Willamette**. One of these selections had **Nootka** as a parent and the others had **Nootka** as a grandparent. One of the dark fruited selections also had the highest soluble solids concentration on samples collected August 5, 2008. In 2007, this selection had soluble solids higher than **Meeker** on one date and slightly less on a second date, with an average slightly higher than **Meeker**. Most of the other selections evaluated in 2008 had soluble solids concentrations similar to **Meeker**. The fruit weight, number of drupelets and drupelet weights were determined for 6 WSU selections, 1 BC selection and 2 cultivars. **Meeker** and **WSU 1499** were the only clones with drupelet weights less than 35 mg. All of the other samples averaged 35-50 mg. Drupelet number and size may influence the ability of the fruit to remain intact during harvest and processing.

WSU 1502 was evaluated in the IQF planting at Burlington and had extremely crumbly fruit, most likely in response to RBDV infection. This selection will not be evaluated further.

Although having a RBDV resistant parent, in testing at WSU Puyallup, **WSU 1499** was found to be susceptible to RBDV. The effect of RBDV on WSU 1499 is not known yet.

Publications/Presentations:

Hoashi-Erhardt, W.K., P.P. Moore, G. Windom and P.R. Bristow. 2008. Resistance of red raspberry genotypes to Phytophthora root rot in field and greenhouse culture. HortScience 43:1367-1370.

Finn, Chad, Patrick P. Moore and Chaim Kempler. 2008. Raspberry Cultivars: What's New? What's Succeeding? Where are Breeding Programs Headed? Acta Hort. 777:33-40.

Moore, Patrick P. and Robert R. Martin. 2008. Screening for Resistance to Raspberry Bushy Dwarf Virus via Pollen Transmission. Acta Hort. 777:379-383.

Weber, C. A., P. Perkins-Veazie, P. Moore and L. Howard. 2008. Variability of Antioxidant Content in Raspberry Germplasm. Acta Hort. 777:493-498.

Moore, Patrick, Penelope Perkins-Veazie, Courtney A. Weber and Luke Howard. 2008. Environmental Effect on Antioxidant Content of Ten Raspberry Cultivars. Acta Hort. 777:499-504.

Jan. 2008. Strawberry and Raspberry fruit display. Northwest Food Processors, Portland, OR.

July 2008. Machine Harvesting Open House. Lynden, WA.

PROJECT: 13C-3755-5641
TITLE: Red Raspberry Breeding, Genetics and Clone Evaluation
CURRENT YEAR: 2009
TERMINATING YEAR: continuing
PERSONNEL: Patrick P. Moore, Professor,
Wendy Hoashi-Erhardt, Scientific Assistant
WSU Puyallup Research and Extension Center, Puyallup, WA

JUSTIFICATION: The Pacific Northwest (PNW) raspberry industry is dependent upon the research programs that it supports. The PNW breeding programs have been an important part of this research, developing cultivars that are the basis for the industry in the PNW. New cultivars are needed that are more productive, machine harvestable, cold hardy and resistant to root rot while maintaining fruit quality. Replacement cultivars for 'Willamette' for early season production, for 'Meeker' for late season production and new cultivars that extend the season are needed. With over 95% 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. This cooperation needs to continue. Cultivars developed by these programs will be of value to the entire PNW raspberry industry.

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

WORK PLAN: 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. Plantings that are currently in the field (seedling plantings, replicated yield plots and breeding plots) will be maintained. Plants in the greenhouse and screenhouses will be maintained.

2. 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. Other traits are fruit firmness, fruit size, fruit color, harvest season, fruit rot resistance, and growth form. Selections identified in the machine harvesting trials as being machine harvestable will be used extensively as parents.

3. Seed from the 78 crosses made in 2008 will be sown in 2008-2009. The goal will be to plant 108 plants for each cross, but will depend on the number of seeds, germination rate and field space.

4. Selections will be made among the seedlings planted in 2006 (9,500 seedlings) and in 2007 (7,100 seedlings). 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.

5. The selected seedlings will be propagated for testing. Shoots for all selections will be collected and placed into tissue culture. Selections that are not successfully established in tissue culture will be propagated by root cuttings and grown in the greenhouse. Shoots will then be collected from these plants for tissue culture propagation.

6. The replicated plantings established in 2005 and 2007 at WSU Puyallup will be hand harvested for yield, fruit weight, fruit rot and fruit firmness.

7. Fruit of promising selections will be frozen for display at grower meetings and subjective evaluation of fruit quality.

Machine Harvesting Evaluation

1. Ten plants of selections propagated as in #5 above will be planted in a grower planting for machine harvesting evaluation.

2. Three plants of each selection will also be planted at WSU Puyallup for observation, use as a parent or future propagation.

3. The machine harvesting trial established in 2007 will be harvested for the first time in 2009. The machine harvesting trial established in 2006 will be evaluated for the second time in 2009. Evaluations will be made multiple times through the harvest season.

4. Fruit of the most promising selections will be run through an IQF tunnel and evaluated, if possible.

5. Samples of fruit from selections that appear to machine harvest well and appear productive will be collected and analyzed for soluble sugars, pH, titratable acidity, anthocyanin content and number of drupelets per fruit.

6. Selections that appear to machine harvest well will be planted 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).

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.

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.

Budget:	**2007-2008**	**2008-2009**
00 Salaries		
Ag Res Tech 2 (0.05) FTE	2,035	2,096
01 Timeslip Labor	19,500	19,500
03 Service and Supplies[1]	19,030	19,067
04 Travel	1,500	1,500
07 Benefits		
Timeslip	2,243	2,145
Ag Res Tech 2	692	692
Total	**$45,000**	**$45,000**

[1] Includes $13,000 for expenses for the following test plantings for evaluation of raspberry selections.

Maintenance of test plantings	
Machine harvesting trial established in 2006 – Honcoop Farms	$3,000
Machine harvesting trial established in 2007 – Sakuma Bros	$3,000
Machine harvesting trial established in 2008 – Sakuma Bros	$3,000
Establishment and maintenance of new test planting	
Machine harvesting trial to be established in 2009 – Honcoop Farms	$4,000

Current Support

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	Title of Project
Moore, P.P. Hoashi-Erhardt	Northwest Center for Small Fruit Research	$82,023	2008-2009	Small Fruit Breeding in the Pacific Northwest

PROJECT: 13C-2755-3641
TITLE: Machine Harvesting Evaluation of Raspberry Seedlings
CURRENT YEAR: 2009
TERMINATING YEAR: 2001
PERSONNEL: Patrick P. Moore, Scientist,
Wendy Hoashi-Erhardt, Scientific Assistant
WSU Puyallup Research and Extension Center, Puyallup, WA

JUSTIFICATION: Over 98% of the raspberries grown commercially in Washington have been harvested for processing use. Virtually all of this production is machine harvested. For a new raspberry cultivar to be successful for the majority of Washington raspberry growers, it must be adapted to machine harvesting. Prior to 2002, selections were made at WSU Puyallup and then evaluated in hand harvested plots at WSU Puyallup. When promising selections were distributed to growers for testing, virtually none of them were adapted to machine harvesting. Beginning in 2002, selections were made at WSU Puyallup and the next evaluation was for machine harvestability with a cooperating grower. The first four plantings included 181 WSU selections. The 2002, 2003 and 2004 plantings have been evaluated two times and the 2005 planting for only one season. There have been 33 WSU selections (18%) that appear to be machine harvestable. This is an improvement from doing the initial evaluation of selections by hand harvesting, but still is not very efficient.

Machine harvesting seedlings should improve the efficiency of selection for machine harvestability. Seedlings would be selected based on their machine harvesting characteristics as well as fruit characteristics (size, color, firmness, flavor). Other raspberry breeding programs have used this method of evaluating seedlings.

OBJECTIVE: Machine harvest seedling populations and make selections based on machine harvesting characteristics.

WORK PLAN:

Year 1 – 2008

Crosses will be made by the WSU Puyallup Raspberry Breeding Program. Seed will be germinated in the greenhouse. . Approximately 2,000 seedlings will be planted with a cooperating grower. The remaining portion of the seedling population will be planted at WSU Puyallup and the normal evaluation procedure followed.

The seedlings will be planted as early in the spring as possible. The cooperator will prepare the site for planting and maintain the planting. The breeding program will supply the plants and assist in the planting. The seedlings will be planted at 4 foot spacing within the row and 10 feet between the rows (1,089 plants per acre). Seedlings will be tied up at the end of the growing season.

Year 2 – 2009

It was proposed to machine harvest the seedlings in 2009. However, in mid-September most of the seedlings were not large enough to harvest. The first harvest season will be postponed to 2010. The budget is changed to reflect maintenance of the planting without any harvests.

Year 3 – 2010

Seedlings will be machine harvested. One person from the breeding program will ride the machine and one or two people will walk the row behind the machine. When a seedling is identified that appears to machine harvest well, the person on the machine will signal the people on the ground to flag the seedling. Seedlings will be machine harvested on a commercial harvest schedule and seedlings evaluated weekly.

Prior to machine harvesting the seedlings, the seedlings will be evaluated from the ground and selections made. Selections will also be made based on the machine harvesting evaluation. The seedlings that were selected by each method will be compared. This information will be used to determine the value of the machine harvesting of seedlings. This information will also be used to improve the ground based selection process.

At the end of the harvest season the most promising seedlings will be propagated for inclusion in a machine harvesting planting.

Year 3 – 2010
The same procedures that were followed in year 2 will be repeated in year 3.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:
Evaluation of seedlings for machine harvestability should result in an increased proportion of selections that are adapted to machine harvesting. This should result in new cultivars that are of more value to commercial growers.

PROPOSED BUDGET:
Sakuma Bros will be the cooperating grower for the 2008 seedling planting. The proposed budget is to reimburse them for their expense in establishing and maintaining the seedling field (2 acres) for the breeding program. Expenses for the breeding program are not included in this proposal.

Budget
Year 1 – 2008-09

Establishment and maintenance	$12,846

Year 2 – 2009-10

Plot maintenance	$2,428

Year 3 – 2010-11

Plot maintenance and harvest	$9,622

Year 4 – 2011-2012

Plot maintenance, harvest and removal	$11,064

Total

PROJECT: 13C-3755-3641
TITLE: Machine Harvesting Evaluation of Raspberry Seedlings
CURRENT YEAR:2009
PERSONNEL: Patrick P. Moore, Scientist,
Wendy Hoashi-Erhardt, Scientific Assistant
WSU Puyallup Research and Extension Center, Puyallup, WA
Reporting Period: 2008

Accomplishments: 2,150 seedlings from 30 crosses were planted at Sakuma Bros. on April 25, 2008. Seedlings from the same crosses were planted at WSU Puyallup in May. With the cool weather in May and June, the machine harvesting seedlings did not put on much growth. By September, few of the seedlings had sufficient growth to justify machine harvesting in 2009. The planting will be maintained in 2009 and the first harvest season postponed to 2010.

Project No.: 13C-3543-4370

Title: Integrating Insect and Mite Management in Red Raspberry

Year Initiated: 2004 **Current Year:** 2008-2009 **Terminating Year:** 2009

Personnel: **Lynell K. Tanigoshi**, Entomologist
Beverly S. Gerdeman, Research Associate
G. Hollis Spitler, Agricultural Research Technician
Washington State University, Mt. Vernon Northwestern Washington Research and Extension Center

Justification:

A review of insecticides and miticides in WSU EB1491, *Pest Management Guide for Commercial Small Fruits* lists 11 synthetic pesticides recommended for effective insect and mite control in red raspberry. Seven of them are "older", broadspectrum, synthetic organic insecticides, specifically, the organophosphates (Malathion, Diazinon), carbamate (Sevin), organic metal (Vendex) and pyrethroids (Asana, Brigade/Capture, Mustang). The remaining ones include the insect/mite growth regulators (Savey, Confirm) and neonicotinoids (Actara) and specific compounds that have been classified by the EPA as reduced-risk, OP replacements and biopesticides (Bt, spinosad, Actara). EPA's FQPA guidelines and current trends in chemical registration portend a need to intensify new chemistry evaluations, particularly the reduced risk and OP alternative insecticides, for which EPA has expedited registration guidelines.

Objectives:

1. Investigate the recent wide population flare-up of economic levels of the yellow spider mite, *Eotetranychus carpini borealis,* and twospotted spider mite, *Tetranychus urticae* in northwestern Washington with areawide scouting and field specific monitoring of miticide trials throughout the 2009 season, including postharvest survey of phytoseiid predators.

2. Continue evaluating prebloom timing, monitoring for drench applications of bifenthrin (Capture) and/or neonicotinoids to the crown and basal canes of red raspberry for control of overwintering adults of the western raspberry fruitworm, *Byturus unicolor* and clay colored weevil, *Otiorhynchus singularis*. Other registered and experimental insecticides will be evaluated using lab bioassays and field tank mixtures.

Procedures:

1. After several years of field testing, Chemtura's Acramite™ (bifenazate) was registered for caneberries in early spring, 2008. From field trials in the Lynden area and discussions with local fieldmen, we concur that Acramite provided fast and extended (i.e., 3-4 weeks) residual control of mixed stages of the yellow and twospotted spider mites emerging at accelerated levels in May through early harvest infestations. Acramite has a PHI of 1 day and REI of 12 hours. Tank mixtures of Acramite and the mite growth regulator Savey™ empirically provided even longer residual control. The different modes of action control their overlapping generations through activity on eggs and growth inhibition of immature life stages and adults. Field testing with Bayer's experimental miticide Envidor™ (spirodiclofen) performed well when applied on a yellow spider mite population that was above our provisional economic injury level of 25 motiles/leaf. Envidor is a mite growth regulator like Savey but differs from it with its unique mode of action that inhibits lipid biosynthesis. Like Savey, Envidor is active by contact on mite eggs and immature stages but differs by controlling adult females. We will continue collecting efficacy data for Envidor for its possible submission to IR-4. However, it will probably have to cue up behind several miticides in the pipeline for IR-4 candidacy for an 'A' priority (i.e., AgriMek™, Kanemite™, Zeal™, Fujimite™)

Field experimental design will be a RCBD consisting of 5 block with plots randomized within each block. Plots will be two posts long and separated by a buffer plot. Blocks will be separated, if possible, by an untreated row to minimize plot sprayer drift. Treatments will be applied with our experimental over-the-row, Rear's hydraulic sprayer. When necessary we will supplement field trials using the above miticides alone and as tank mixtures, with detailed leaf disc bioassays to evaluate spider mite mortality more precisely. We will also conduct site specific screening for spider mite tolerance to the 0.05-0.1 field rates of Capture and Mustang™ (zeta-cypermethrin).

2. Pending more normal, prebloom weather next season compared with 2008, we will field trial drench applications of Actara™ (thiamethoxam), Assail™ (acetamiprid), Mustang and BASF's experimental BAS 320 I alone or in combination as an integrated management technique for adult clay colored weevil (black or rough weevil, too), adult western raspberry fruitworm and the yellow spider mite, since we know that yellow and twospotted spider mites overwinter as diapausing adult on the crown/canes and duff of fruiting canes optimizing both timing and control measures. Field trials with BAS 320 I on black and rough strawberry root weevils in strawberry and lab bioassays confirmed this novel, new chemistry class of sodium channel blocker insecticide shows promise for its submission to IR-4 in the near future. Based on field monitoring and observations for leaf notching and bud feeding, along with good field conditions in April, we will make drench applications with a modified Rear's hydraulic plot sprayer equipped with two Turbo Floodjet™ nozzles to deliver up to 400 gallons/acre. Foliar applications will be applied with the traditional over-the-row boom mounted on a plot sprayer. Treatments will be replicated five times in plots measuring 2 post lengths arranged in a RCBD. Controlled laboratory bioassays of various aqueous concentrations of insecticides and surfactants will be applied with a precision Potter Tower™ spray application to trifoliate leaf bouquets.

Anticipated Benefits and Information Transfer:
Pending registrations of additional insecticides and miticides with differing modes of action, will result in the development of an integrated management system for root weevils, leafrollers and aphids while promoting biological control of spider mites. Results of a multi-year program going back to 1995 are expected to advance grower understanding of control methods for emerging adults of the western raspberry fruitworm and clay colored weevil with effective insecticides applied as a prebloom basal application. In cooperation with WSU Whatcom and Skagit County Cooperative Extension personnel, research information will be disseminated at regional and national growers' meetings as well ass through local, regional and national publications. Newsletters and WSU Mount Vernon REC's website will update industry on new developments as appropriate.

Budget:

		2009
00	Salaries[1]	$4,000
01	Wages[2]	2,000
03	Goods and services[3]	300
04	Travel[4]	800
07	Employee benefits (36% of 00)	1,600
	Employee benefits (18% of 01)	360
Total		**$9,060**

[1]Research Associate
[2]Time slip assistance
[3]Lab and sprayer supplies and equipment
[4]To and from plots in vicinity of Mt. Vernon REC

Project No.: 13C-3543-4370

Title: Integrating Insect and Mite Management in Red Raspberry

Year Initiated: 2004 **Current Year:** 2008 **Terminating Year:** 2009

Personnel: **Lynell K. Tanigoshi**, Entomologist[1]
G. Hollis Spitler, Agricultural Research Technician
Beverly S. Gerdeman, Research Associate
Washington State University, Mount Vernon Northwestern Research and Extension Center

Reporting period: 2008

Accomplishments:

Western raspberry fruitworm.

Laboratory bioassays.

Western raspberry fruitworm adults were collected on 23 June from a mature 'Totem' field in Lynden, WA. Two recommended rates for the recently registered systemic neonicotinoid Assail™ 70WP (acetamiprid) was compared with Brigade™ (bifenthrin) and BASF's experimental BAS 320 I to control the adult western raspberry fruitworm. Residual leaf dip bioassays were conducted using raspberry leaves whose stems were inserted into water-filled vials, plugged with cotton. Individual trifoliate leaves were dipped in respective deionized water/insecticide solutions for 5 sec, air dried and placed in 5 inch diameter Petri dishes. Three adult western raspberry fruitworm adults collected in mid-June, were placed into each of the seven arenas and maintained at room temperature. Each treatment was replicated seven times. Adult mortality was assessed at 24 hour intervals. Within 24 hours, 100% mortality was observed for adult beetles exposed to Assail and Brigade. All of the adults exposed to BAS 320 I leaves were in a moribund state. They were all observed on their backs, appendages moved when probed, many expressing diarrhea and females involuntarily laying eggs. We scored these adults in the mortality category because they no longer fed and never recovered. We conclude that the insecticides currently labeled for caneberries will effectively control western raspberry fruitworm.

Clay colored root weevil.

Laboratory bioassays

Clay colored weevils (CCW) were collected from the Lynden area on 'Meeker' red raspberry on 26 June, 2008. Individual trifoliate leaves were placed in water-filled vials plugged with a cotton roll plug. Each treatment consisted of a total of 30 weevils placed on 6 individual leaf arenas held in 5 inch diameter Petri dishes held at room temperature. These leaf arenas were each dipped in respective deionized water-insecticide solutions for approximately 5 sec and air-dried. After 1 day posttreatment, Brigade™ (bifenthrin) and two rates of experimental BAS 320 I expressed complete mortality of CCW through contact and ingestion under lab conditions. Under these conditions, the results provided no evidence for the onset of CCW resistance to Brigade as was suggested from 2006 results from a field population collected at the same location. BAS 320 I represents a new class of chemistry (Group 22) that controls insects by ingestion, blocks the flow of sodium ions and does not require metabolic bio-activation to become insecticidal. CCW exposed to BAS 320 I were in a moribund state after 1 day posttreatment. Symptoms observed were cessation of feeding, metabolic distress (e.g., diarrhea) and uncoordinated movements that resulted in prolonged morbidity and death that extended to12 DAT (e.g., 63% low rate, 100% high rate). These post exposure responses are similar for other species of root weevils when exposed to neonicotinoids such as Actara. Though the target site of BAS 320 I differs from the neonicotinoids, population mortality upon exposure to Actara often is variably prolonged for 3-5 days as well in adult root weevils. We scored the moribund CCW's as dead because they are incapable of pest status and further impacting field damage. The insecticidal effect on root weevils is irreversible, as observed for pyrethroids and neonicotinoids, but slower acting compared with the mode of actions of the old carbamate and OP chemistries. BAS 320 I is pending registration in blueberry and we will suggest it as an 'A' priority next year for strawberry and caneberry IR-4 residue projects.

Spider mites.
Yellow spider mite field trial.
Population levels of spider mites in northwestern Washington exceeded expectations given the unseasonably cool, wet spring and early mild summer temperatures. This in contrast to 2007 when spider mite populations were generally non-economic ones, especially in northwestern Washington. Problematic flare-ups of the yellow spider mite (YSM), were particularly severe in the Northwood area of Lynden where late May population on both 'Meeker' and 'Willamette' exceeded our provisional treatment threshold level of 25 motile life stages per leaf by 10 to 100-fold. Female YSM emerge from diapause and disperse approximately two weeks earlier than do twospotted spider mites (TSSM). YSM migrates to distal primocane foliage along the top trellis wire of red raspberry in April to May. Our research data has shown the cooler spring and fall temperatures favor YSM. The sudden onset of warm weather stressed new foliage and provided the right conditions for a mid-season (May to August), region- wide flare up of mostly YSM with lesser numbers of TSSM and European red mite.

On 8 July 2008, we compared 2 rates of the recently registered Acramite 50WS (bifenazate), one each of Acramite 4SC and experimental Envidor 2SC (spirodiclofen) with our standard Vendex™ (fenbutatin-oxide) on a mature 'Meeker' site in Lynden, WA. Envidor is a Group 23 acaricide that inhibits lipid synthesis in plant feeding mites. Applications were applied with a Rear's hydraulic plot sprayer equipped to deliver 122 gpa at 1.8 mph with 2 8004 nozzles on top of boom, with both vertical arms each equipped with 5 D3-45 Tee Jet nozzles. Treatments were replicated five times and plots measure 30 feet long by 10 feet wide. A total of twenty-five leaflets were taken at random from primocanes at chest height from both sides of the row. These samples were processed with a mite brushing machine and motile life stages of the YSM and predatory mites, *Neoseiulus fallacis* recorded for each plot. Compared with the untreated check, all of the miticide treatments were not significantly different from each other through 44 days posttreatment. After 6 days posttreatment, YSM populations were reduced by: 26-fold (Acramite 50WS @ 1.0 lbs (0.50 lb(AI)/acre + silicone surfactant); 15-fold (Acramite 50WS @ 1.0 lbs (0.50 lb(AI)/acre + silicone surfactant); 36-fold (Acramite 4SC 16.0 fl oz/acre (0.50 lb(AI)/acre + silicone surfactant); 15-fold (Vendex 50WP @ 1.0 lb(AI)/acre + silicone surfactant; 16-fold (Envidor (spirodiclofen) 2SC @ 18 fl oz/acre (0.28 lb(AI)/acre + Volck Supreme oil (1% v/v). These field results confirm our past results with Acramite 50WS, while Chemtura's 4SC formulation was equally efficacious as was our warm weather standard Vendex 50WP. Bayer's experimental mite IGR, Envidor, provided quick knockdown of motile life stages of YSM at 3 DAT. Bayer recommended performance evaluation be made 4-10 days following application. Our leaf counts indicated Envidor was relatively inactive against *N. fallacis.* Envidor's selectivity, quick knockdown and long residual are features shared by Acramite and worthy of submission to IR-4 for a residue project in caneberries.

Project Number: 13C-3419-7297

Title: Postemergence Canada Thistle and Bindweed Control in Red Raspberries

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

Reporting Period: 2008-09

Accomplishments:

This project is the second year of testing for the effects of two formulations of Casoron (4G and CS) and Stinger applied early or late to established red raspberries. Timings would be similar to when Canada thistle or field/hedge bindweed would be at a good stage of growth for herbicide treatment. Data will be presented at the red raspberry commission meeting for project review and at winter grower meetings during 2008-09.

Results:

Plots were established in healthy, third-year 'Meeker' raspberries at WSU Mount Vernon NWREC. Each plot was 30 feet long by 5 feet wide and contained a single row of raspberries. Herbicide applications were made either as a directed spray to the base of the canes (liquid Casoron or Stinger) or sprinkled among the canes (granular Casoron). Herbicide applications were made March 27 (PRE), June 26 (early postemergence, EPOST) and July 18 (late postemergence, LPOST). Floricanes had just begun breaking bud and the first primocanes were visible above the soil surface at the time of the PRE application, floricanes were in late flowering at the time of the EPOST applications, and the LPOST applications were made three days prior to first harvest.

Injury to primocanes was noted August 12 and weed control October 4. Berries were machine harvested ten times from late July through early August and total berry weight per plot was recorded. Primocane counts in treated plots will be recorded when raspberries are in winter dormancy. The experiment is a randomized complete block with four replicates.

As this was a young raspberry planting, few weeds were present on which to evaluate weed control (non-treated plots showed 95% free of weeds); weed control in treated plots ranged from 98 to 100%. Primocane injury was noted after most treatments, with the highest injury resulting from treatment with Casoron applied in July (evaluation at one month after treatment). The liquid Casoron formulation (Casoron CS) at either timing caused a similar level of primocane injury as granular Casoron (ranging from 11 to 19%). Stinger applications caused only slight injury to primocanes (10 to 13%). Floricanes were not significantly injured by any herbicide application, and berry yield was also not significantly affected. Primocanes will be measured this winter to determine if any of these treatments caused lasting injury to red raspberry.

An additional herbicide test is being conducted with industry funding in second-year red raspberries. These products include Chateau, Matrix, two numbered Valent compounds, and Callisto. Canes were cut during midwinter, and products were applied in a mix with Roundup to control emerged weeds.

Table 1. Primocane and floricane injury, weed control, and berry yield following application of several herbicides in red raspberry.

Treatment[a]	Timing	Rate	Crop injury[b]	Weed control[c]	Berry yield[d]
		product/a	%	%	kg/30 ft
Casoron 4G	PRE	100 lbs	11 b	100	25.1
Casoron CS	PRE	2.8 gal	13 b	100	23.1
Stinger	EPOST	5.3 fl.oz	5 c	98	29.3
Stinger	EPOST	10.7 fl.oz	9 bc	99	25.9
Casoron 4G	EPOST	100 lbs	19 a	99	26.2
Casoron CS	EPOST	2.8 gal	18 a	100	26.3
Stinger	LPOST	5.3 fl.oz	10 b	98	26.4
Stinger	LPOST	10.7 fl.oz	13 b	99	26.5
Non-treated	---	---	0 d	95	27.0

Means followed by the same letter are not significantly different ($P < 0.05$).
[a]Herbicides were applied March 27 (PRE), June 26 (EPOST), and July 18 (LPOST).
[b]Crop injury estimated August 12 (no crop injury noted October 4).
[c]Weed control estimated October 4.
[d]Berries machine harvested eight times from late July through early August.

Project No: 13C 3419 7297

Title: Postemergence Perennial Weed Control in Red Raspberries

Year Initiated: 2009-10 **Current Year:** 2009-10 **Terminating Year:** 2009-10

Personnel:

Timothy W. Miller, Extension Weed Scientist, WSU Mount Vernon NWREC
Carl R. Libbey, A/P Assistant Scientist, WSU Mount Vernon NWREC

Justification:

Perennial weed species generally become more important the longer raspberry blocks are left in production. Horsetail (*Equisetum* spp.), quackgrass (*Elymus repens*), broadleaf dock (*Rumex obtusifolius*), Canada thistle (*Cirsium arvense*), dandelion (*Taraxacum officinale*), white clover (*Trifolium repens*) and hedge bindweed (*Calystegia sepium*) have long been weedy in western Washington. 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 few seasons on a new raspberry block, when raspberry plants are small and not as competitive. If not controlled when young, perennial weeds become increasingly difficult to kill, ballooning herbicide and labor costs and becoming a major factor in reducing the longevity of raspberry plantings. Conversely, controlling seedling perennials the first few seasons likely will result in sizeable weed control savings over the life of the raspberry block since raspberry plants that become more quickly established are more capable of slowing weed seed germination in the row (through canopy shading) while at the same time resisting encroachment from outside the row (through shading and vigorous cane growth).

It is important to gain new tools for controlling established Canada thistle in established raspberries. Last year's trials with postemergence (POST) Stinger (clopyralid) and Casoron (dichlobenil, both granular and liquid formulations) in healthy raspberries at WSU Mount Vernon NWREC were encouraging. Primocane injury was generally low from directed-sprays of Stinger to the base of the floricanes; primocane injury from Casoron applied after emergence was moderate, but transitory. Importantly, floricane injury and berry harvest were not significantly impacted by these applications. Since 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.

Two additional POST herbicides with potential for registration in raspberry have advanced through IR-4 testing during 2007 and 2008. These are Matrix (rimsulfuron) and Sandea (halosulfuron), which offer improved control of quackgrass and yellow nutsedge, respectively. A third product with considerable POST activity is Callisto (mesotrione). I have some crop data dating back to the early 2000's of these products, but combination treatments at with either Stinger or Casoron at lower rates than when applied alone may prove helpful to improve weed control and lessen potential for injury to raspberry crowns.

Objective:

To test Stinger, Casoron, Matrix, Sandea, and Callisto in various mixtures applied POST for control of several perennial weeds in established red raspberries.

Procedures:

Plots will be established in 2009 in perennial weed-infested raspberries near Mount Vernon. Herbicide applications will be made for several combinations of these herbicides in early spring (Casoron, granular and liquid formulations) and early summer (Stinger, Callisto, and Matrix/Sandea). A typical application sequence could be Casoron (4G) in March followed by Stinger + Matrix in late June. Most sequences/combinations of these five herbicides will be included in this trial. Additional Perennial weed control will be evaluated, as will herbicide effects on raspberry yield, berry size, and primocane growth.

Anticipated Benefits and Information Transfer:

If positive, data from this experiment will be used to support new herbicide registrations in raspberries for Matrix, Sandea, Stinger, and Callisto, and to expand the existing label for Casoron. 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:

Amount allocated to PI by Red Raspberry Commission for FY 2008-09: $ 3,986

	Requested 2009-10
Salaries[1]	$ 1,500
Time-slip wages	1,000
Operations (Goods & Services)	500
Travel	
Projected Needs[2]	250
Meetings	0
Other	0
Equipment	0
Employee Benefits	
A/P Ass't Scientist (38%)	570
Time-slip (16.6%)	166
Total Request	$ 3,986

[1]Salary for A/P scientific assistant Carl Libbey (0.59 FTE funded by WSU, 0.41 FTE funded by my program; benefits (38%) included in employee benefit line.

[2]Travel is for plot establishment, maintenance, and harvest.

Other Support of Project:

Herbicides are typically provided by herbicide manufacturers.

Current & Pending Support

Timothy W. Miller

Extension Weed Scientist, WSU Mount Vernon

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
	Biofuel Initiative				
Miller & Cogger	10A 3419 8008	40,000	7/1/08 to 6/30/09	10	Biofuels cropping systems in western Washington
Yenish, Miller, & Burke	10A 3019 8015	40,000	7/1/08 to 6/30/09	10	Weed management in oilseed crops
	WA Blueberry Com.				
Miller	13C 3419 5229	5,713	7/1/08 to 6/30/09	5	Weed control in blueberries
	WA Bulb Com.				
Miller	13C 3419 8228	1,327	7/1/087 to 6/30/09	5	Herbicide combinations for weed control in ornamental bulbs
	WA Strawberry Com.				
Miller	13C 3419 8228	10,768	7/1/087 to 6/30/09	10	Weed control in strawberries
	WA Raspberry Com.				
Miller	13C 3419 3297	3,986	7/1/08 to 6/30/09	5	POST Canada thistle & bindweed control in red raspberry
	NARF				
Miller	13K 3419 5228	7,039	7/1/08 to 6/30/09	5	Weed control in green peas
Miller	13K 3419 6228	8,715	7/1/08 to 6/30/09	5	Weed control in cucumbers
Miller	13K 3419 7228	6,939	7/1/08 to 6/30/09	5	Weed control in vegetable seed
Cogger et al.	USDA IOP	644,232	7/1/08 to 6/30/12	5	Designing production strategies for stewardship and profits on fresh market organic farms
	Pending: Emerging Issues				
Walters et al.	second year request	46,323	7/08-6/09	5	High value crops under high tunnels in western Washington
Fullerton, Hopps, Miller, & Bachleda	SBIR new request	85,000	5/08 to 4/09		Brassica seed meal byproducts

Title: Red Raspberry Cultivar Development

Year Initiated: 2001 **Current Year:** 2008-2009 **Terminating Year:** 2009

Amount requested from the LMHIA $ 7,000

Personnel: Chaim Kempler (Research Scientist)
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Collaborators: Pat Moore, WSU Puyallup.
Chad Finn, ARS-USDA Corvallis.
Tom Forge. Nematology/Plant Pathology AAFC PARC Agassiz
Andrew Jamieson Berry Breeder AAFC Kentville NS

Project Description:
This program develops red raspberry cultivars, with an emphasis upon creating varieties exhibiting suitability for machine harvesting, suitability for processing, dark fruit, winter hardiness, and resistance to RBDV, root rot, and aphids. Of particular importance is to speed up the release of cultivars that are disease and pest resistant, to replace the industry standard, Meeker.

Project Summary: The PARC AAFC breeding program is developing varieties adapted to the PNW region. Chemical pest control measures are becoming increasingly unavailable, making genetic resistance and tolerance more important. Breeding for resistance is the most sustainable and preferable way to address industry concerns and needs. The scientific approach for development of improved berry cultivars employs recurrent mass selection. This consists of hybridization among the best selections, followed by selection. This method exploits additive polygenes, providing minor gene resistance, which is not as vulnerable to being overcome by changes in pathogen population genetics, but gives lower levels of resistance. Exploring a diverse gene pool by including various species allows us to broaden the genetic base and introduce new sources of resistance that are more effective and slower to be overcome by evolving pathogen populations.
The objective of the project is to fasten the process of releasing potential cultivars to the propagators for multiplication and fast testing on growers' fields. We believe that the fastest way to introduce new cultivars to the industry is planting them on growers' fields' trials. We propose a project to develop raspberry cultivars and to soon test them on growers' field.

Justification:
The Agriculture and Agri-Food Canada (AAFC) breeding program supports the berry industry throughout the Pacific Northwest (PNW) and produces new berry varieties that enhance production. Of particular importance to the industry is the development of cultivars displaying disease and pest resistance, such as resistance to raspberry bushy dwarf virus (RBDV), root rot, fruit rot and raspberry mosaic virus (RMV). The RMV complex can be a limiting factor in raspberry production but can be simply controlled by introducing resistance to its aphid vector. Reaction to the aphid vector *(Amphorophora agathonica)* of the RMV is used by the Pacific Agri-Food Research Centre (PARC) program as a primary screen in the seedling stage. All the cultivars that are released from this program are resistant to the common biotype of *A. agathonica*. A resistance-breaking biotype of *A. agathonica* has been found in North America but is not causing problems, as it does not colonize very well on resistant cultivars and is not yet a vector of RMV. Raspberry bushy dwarf virus (RBDV) causes symptoms that adversely affect fruiting and growth in susceptible raspberry cultivars and selections. The combination of RBDV with raspberry mosaic virus (RMV) has been shown to be particularly detrimental to growth and fruiting. The most common strain of the RBDV virus has been controlled by breeding for resistance. Of cultivars released in the past, Haida and Nootka, and Chilcotin are resistant to RBDV. Cowichan, released in 2001, has given some hope to the industry because it is suitable for mechanical harvesting and that escapes RBDV. Close to one million Cowichan plants have been planted across the PNW since its release and although it grows very vigorously, it lacks root rot resistance needed for success in infected soils, or heavy and poorly drained

soils. More than one million plants of Chemainus (BC89-33-84) has been planted on test plots throughout the PNW already. This cultivar produces large, glossy, dark, firm fruit that is suited both for processing and the fresh market and machine harvests very well. Its fruit is very suited for the IQF processing market. Saanich (BC89-34-41) also recently released from the PARC program and has been extensively planted throughout Washington state and the PNW with close to 250 thousand plans. Saanich attracts attention mainly for its high yield, its exceptionally good fruit quality which is very suited for IQF, and its suitability for mechanical harvesting. It is also very slow to become infected with RBDV and is moderately resistant to root rot. The sale of PARC released cultivars increase between 2001 to 2008 from 9% to more than 31% of the Meeker plant sale. It is abusive that seeing what the producer plant is the simplest test of value.

The PARC breeding program is using selections of *R. strigosus* as new sources of resistance to the root rot caused by *Phytophthora fragariae.* F1 to F3 are tested and used in back crosses to incorporate resistance into cultivars and advance selections. A hybrid between Tulameen and *R. strigosus* (BC90-19-34) has shown greenhouse and field resistance. Other resistant cultivars are identified and used in crosses to improve root rot resistance with the goal of combining root rot and RBDV resistant cultivars. Recently we had also developed greenhouse screening technique to screen cultivars selections and germplasm that help us to evaluate the value of our selection at early stage and during the early stages of testing.

Selections with improved fruit quality (size, firmness, and color) and with extended ripening dates will improve production and market appeal. Selections with fruit qualities suitable for processing will benefit the value-added processing sector of the industry. Other important traits include improved fruit size, increased fruit number per lateral, reduced spines, increased fruit firmness, fruit rot resistance, ease of harvest, low chilling requirements and winter hardiness. In WA and BC, winter hardiness is a primary concern in the selection procedure. Unusually cold test winters that occur during the selection years allow for selection of more hardy genotypes. Selections that go dormant early and break dormancy late are probably the most desirable to select for cold hardiness.

The PARC breeding program has broadened its genetic base by drawing on different sources. Parents derived from various species are used. Furthermore, germplasm from other breeding programs around the world is used. This germplasm is tested and used to incorporate desirable traits into PARC selections. Also, a wide range of wild species are used. Three cultivars released from the program (Tulameen, Qualicum and Malahat) have the black raspberry, *Rubus occidentalis* L., in their derivation. In addition, Malahat is a descendant of *R. phoenicolasius* Maxim. Some of the potential cultivars that are now in growers' trials contain *R. occidentalis* in their derivation. Kitsilano has *R. crataegifolius* in its derivation, while Nanoose, BC90-8-11, BC90-8-20, and BC92-6-41 have the Dalhousie Lake selection of *R. strigosus* Maxim. in their derivations. BC90-19-34 is hybrid between Tulameen and the 'Lake George' selection of *R. strigosus.*

The PARC breeding program emphasises releasing potential cultivars to the propagators for multiplication and fast testing on growers' fields. We believe that the fastest way to introduce new cultivars to the industry is planting them on growers' fields.

Objectives:

Develop red raspberry selections, stressing suitability for machine harvesting, dark fruit, winter-hardiness, resistance to root rot, resistance to divergent aphid biotypes, and resistance to RBDV. Specific goals include:

-The fast release of potential cultivars to propagators to multiply for testing on growers' fields.
-Cultivars that combine resistance to pollen infection from RBDV and to root rot.
-Manageable plant habit that is suitable for machine harvesting and produces high yields, superior fruit quality, good flavour, size, firmness, small drupelets, ease of harvest, and fruit rot resistance.
-Hardy plants that withstand low temperatures, desiccating winds and late breaking dormancy.

-Dark color fruit for processing that exhibits small drupelets that are suited for IQF.
-Large, firm, light color fruit that is suited for the fresh market.
-Aphid resistance, which controls the Raspberry Mosaic Virus Complex (RMVC).
-Resistance or tolerance to cane diseases (such as spur blight, cane *botrytis* and cane spot), spider mites, lesion nematodes, bacterial blight, crown gall and to leaf diseases such as rust and powdery mildew.
-Adequate replacement cane production.
-cultivars with enhanced and higher nutraceutical/nutritional benefits

Procedures:
*Experimental Details:*This will involve the harvest of the fruit, ease of harvest assessment, fruit firmness determinations with a pressure gauge, postharvest rot determinations, soluble solid and acidity determinations, and observations of various pests and diseases under field conditions. Seedlings will be screened for aphids. Advance selections will be screened for root rot resistance. Evaluation will continue on all the selections in the test plots at the Abbotsford Sub-Station. The evaluation includes yield and fruit quality determinations, ease of harvest and reactions to various pests and diseases, including fruit rot, cane disorders, aphids (which vector the mosaic virus complex), raspberry bushy dwarf virus and root rot (*Phytophthora fragariae)* and winter damage. Advanced selections will also be used in further breeding to develop a broad base of resistance.
Activities:
- Create 2009 crossing blocks – cross selections that were identify to stand up to root rot under field and greenhouse conditions with cultivars and potential cultivars that have RBDV resistant parents in their derivation in order to improve and develop cultivars that are Root rot and RBDV resistant.
- Evaluate the seedling populations planted in 2006.
- Continue propagation of advanced selections for WRRC and RIDC machine harvest evaluation.
- Establish replicated trials at the Abbotsford substation to assess advanced selections suitable for processing and machine harvest.
- Evaluate advanced selections in growers' fields throughout the PNW to assess productivity, machine harvesting, and resistance to root rot and RBDV.
- Release potential cultivars to the propagators.
- Supervise distribution of advanced selections to North American propagators and growers and subsequently monitor their performance.
- Evaluate BC92-6-41 and others advance selections on large growers' trials.
- Name BC92-6-41 a selection that is highly resistant to root rot, very slow to get infected with RBDV, machine harvest well and is suited for the IQF and fresh markets.
- Conduct collaborative research with Robert R. Martin, USDA-ARS, Corvallis, Pat Moore and a Courtney Weber to develop a marker assistant process to identify RBDV resistance at the seedling stage. When available, this procedure can shorten the usual 10 years or more that it takes for testing of resistance into a simple screening process that can be done before the seedlings are planted in the field.

Anticipated Benefits and Information Transfer:
Six out of the twelve research priorities determined by the Red Raspberry Commission are addressed in the objectives of the PARC breeding program and are part of the objectives. It is well established that breeding for resistance is the most sustainable and preferable way to address industry concerns and needs. The program emphases on developing and releasing RBDV resistant cultivars and *Phytophthora* root rot tolerant cultivars. All PARC releases are resistant to aphids, which transmit viruses and cause insect contamination at harvest. Many of the PARC releases extend the harvest season are suited for the fresh market and have some fruit rot resistance. The results of the evaluations will be directly available to the PNW red raspberry industry. In the coming years, the evaluations will help determine the commercial suitability of advance selections. It will also allow the PARC breeding program to continue its breeding activities, identifying new potential cultivars to be released for propagation and further testing.

Budget: (2008/09)
Amount requested from the $US 7,000

Washington Red Raspberry Commission (WRRC)	**$CD 7.000**
Raspberry Industry Development Council (RIDC)	$CD 15,000
Lower Mainland Horticultural Improvement Association (LMHIA)	$CD 6,000
AAFC MII[1]	**$CD 44,818**

Resource commitments by	MII	Industry(Cash)	Industry(in-kind)
Salary	25,000	-	-
Benefits	5,000	-	-
Student salary	-	17,960	-
Travel	-	1,000	-
Operating	5,865	1,700	-
RIDC technical coordinator			2,500
RIDC use of growers land			5,000
RIDC plant propagation for growers trials			2,250
WRRC plant propagation for the Abbot. Site (by Sakuma)			900
RIDC Virus testing			4,188
RIDC soil testing			480
WRRC trials 05 planting			2,200
WRRC trials 05/06/07 planting			1,700
WRRC technical coordinator			1,500
Admin cost on industry in-kind	3,108	-	-
Admin cost (15%)	5,845	3,140	-
Total	**$ 44,818**	**$ 23,800**	**$ 20,718**

Budget Summary

Contribution	
RIDC	15,000
WRRC	**7,000**
LMHIA	6,000
Industry in-kind	20,718
Total industry (Cash + in-kind)	**48,718**
AAFC-MII	44,818
Total for project	**93,536**
Administration cost (AAFC-PARC)	12,093
Total cash funds available to the program	**60,725**

[1] MII has been approved for 4 years 2007-2010 conditional to industry funding)

2008 PROGRESS REPORT

Title: Red Raspberry Cultivar Development for the Pacific Northwest

Personnel: Chaim Kempler, Fruit Breeder
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Summary: In 2008, 16 PARC selections were planted at the WRRC site for machine harvest evaluation. Yield data from more than one hundred plots was collected from trials planted in 2004, 2005 and 2006; data has been analyzed and presented in this report. In the coming winter BC92-6-41 will be released and named. This selection is suited mainly for the fresh market but it also machine harvested well and can be used for processing and IQF. BC92-6-41 is already propagated and available for field testing. The recently released cultivars, Saanich and Chemainus, are performing very well on growers' field. They are planted extensively by growers and are becoming important cultivars for the industry. This season 3 plantings were evaluated for machine harvest-ability the results are presented in the report.

Accomplishments:
The latest releases from the PARC program performed very well; Chemainus (tested as BC89-33-84) machine harvests very well, producing high quality fruit that is suited for both the fresh and the IQF processing markets. Saanich (tested as BC89-34-41), has gained wide acceptance by commercial producers because of its large yields of high quality fruit that machine harvest very well and produce a top quality IQF product.

This year three machine harvest trials were harvested and evaluated. Two were planted at Randy Hancoop's (Lynden) in 2005 and 2006 and one at Rudy Janzen's (Abbotsford) in 2006. The results identify several selections that appear to harvest very well (table 1). Some of the selections are already in advanced propagation stages and will be released for growers' trials. The Janzen site in Abbotsford was especially valuable because of the high level of root rot which provided extra information and screening for root rot susceptibility.

During the 2008 harvest season, the 2004, 2005 and 2006 plantings were evaluated for yield, fruit traits and harvest season. Harvest data is presented in Tables 2-4. Thirty-two selections tested RBDV positive for the first time, and most of them were discarded. Fifty-eight new selections mostly from parents combining resistance to RBDV and root rot were identified from the 2005 crosses. They will all be propagated by tissue culture and will then go through root rot screening before being field planted in the spring for yield and machine harvesting evaluation. Thirty-two new crosses were made; most with one or two parents that are resistant to root rot and RBDV. They are being propagated and will be planted in the spring of 2010 after a screening for resistance to aphids. Five thousand seedlings were screened for resistance to aphids; thirty-five hundred of them were selected to be planted in Abbotsford where they will be evaluated and selected in 2010 and 2011.

Notes on cultivars and potential new cultivars:

Chemainus (BC82-5-84 x Tulameen): Tested BC89-33-84, a mid-season processing and fresh market type that produces large-sized, medium-dark color attractive berries. 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, perfect in shape with fine drupelets, and so is very suitable for IQF and also for the fresh markets. The plant has excellent vigor, producing plenty of replacement canes. Its primocanes are green with no spines and its 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 *Phytophthora fragariae* showing good growth in comparison to Meeker and Malahat. Chemainus has been planted widely in the PNW with large acreages already planted (tables 2abc, 3 and 4).

Saanich [(Algonquin x Chilliwack) x (Nootka x Glen Prosen)]: Tested as BC89-34-41, the cultivar is a very promising release from the breeding program. It is very productive, producing 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, fine drupelets and a very pleasant sweet flavor that is comparable to Tulameen. Because of its small drupelet size the fruit IQF 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 selection, although exposed to high pressure of RBDV for many years, has been very slow to show RBDV infection and to date has not tested positive on any of the commercially planted fields. It was released because of its productivity, suitability for machine harvesting and exceptionally high fruit quality that is suited for IQF. It produces medium-sized, medium-light-red firm fruit. Its very sweet flavor might also make it suited for specialty fresh fruit markets (tables 2abc, 3 and 4).

Nanoose (BC86-41-15 x BC83-15-15): Tested as BC90-6-2, it is the most recent named cultivar. It was selected from a cross between a root rot resistant *R. strigosus* derivative and a selection from a cross between Comox and Algonquin. We have noted it for its short internodes, compact plant habit, extremely late production season and its very large, meaty fruit. Fruit is round, firm and dark red in color which makes Nanoose suited also for processing. It machine harvests very well, producing high yields of very dark, firm fruit that is not suited for IQF processing because its breaks when exposed to liquid nitrogen. It is very suited for the late fresh market due to its long harvest season, late producing period and very large and very firm fruit. The dwarf growing habit of the plant
might allow growing it with less support and saving on pruning labor (tables 2ab, 3 and 4).

New selections for growers' trials:
BC92-6-41 (Chilliwack x BC86-41-15): This selection will be named this coming winter. It was identified for its high field resistance to root rot and its medium red bright attractive fruit. It is from a 2nd back cross from the *R. strigosus* Dalhousie Lake 4 clone. This will be the first cultivar that was developed from this wild source of *R. strigosus.* BC92-6-41 produces high yields of fruit that is easy to harvest. In machine harvest trials it harvested well producing fruit that may be suited for IQF. In those field trials it shows also excellent resistance to root rot like symptoms (table 1). The fruit is conical, medium red color with low gloss and good flavor; suited for fresh market production and also for IQF and processing. It is productive and keeps good size over its long harvesting season. Limited numbers of plants are available for testing from the propagators (Tables 2abc 3 and 4).

BC90-8-11 (BC86-41-15 x Qualicum): This is a 2nd backcross from a *R. strigosus* Dalhousie Lake 4 clone. It produces a large mid-to-late season crop that is most suited for the fresh market but also might be acceptable for processing. 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.

BC90-8-20 (BC86-41-15 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 is resistant to aphids and might also be resistant to the resistance-breaking biotype of aphid. It does not appear to be field resistant to root rot.

BC90-11-44 (Algonquin x Qualicum): This is a very productive selection that produces over an extended harvest season. The attractive fruit is large in size, glossy and firm with very fine drupelets 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. It appears to be susceptible to aphids.

BC92-5-47 (Kitsilano x BC86-40-6): Productive selection producing mid-size fruit. Originates from a 3rd back cross from the *R. strigosus* the Dalhousie Lake 4 clone. It has performed well in MH trials and has yet to be tested on larger trials. The fruit is medium size (3.8 g) dark, firm and round shaped with fine drupelets and may be suited for IQF processing. Fruit color is dark as Meeker and tends to be dull with low gloss. It is not resistant to RBDV and has above average field resistance to root rot. The plant is productive with strong laterals.

BC96-22R-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 parent was selected because of its resistance to root rot. In machine harvesting trials, it harvested very well, producing fruit as dark colored as Meeker. The fruit is attractive and large in sized (4.7g). It is round shaped 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's season and is short and concentrated. It appears to have very good field resistance to root rot. Although the parents of this selection are susceptible to RBDV, selection BC96-22R-55 never tested positive to RBDV. It can be assume that after about 10 years of exposure to the virus it is very slow in getting infected (tables 2b and 4).

BC97-30-27 (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 to that of Meeker and more similar to Willamette. It is not resistant to RBDV, stand well to root rot and it is resistant to aphids.

BC1-16-8 (Newburgh x Glen Rosa): A very productive selection producing high yields, large fruit that mature a few days earlier than Meeker. Fruit is dark with small drupelets that hold together very well so it may IQF very well. It performed very well in the MH trials (Tables 2a and 3).

BC1-50-2 [Saanich x (Newburgh x Tulameen)]: This is a very productive selection producing large firm high quality fruit that is light colored with fine drupelets. It is mainly suitable for the fresh market. Fruit is long conical and uniform in shape, fruit color is light medium red with low reflecting gloss. Its high quality and firmness will make excellent fresh market (tables 2a, 3 and 4).

BC3-14-12 (Cowichan x Esquimalt) Very productive selection suited for the processing and the fresh market that ripen almost a week later than Meeker and produce large fruit with thick walls and meaty and is shaped like a barrel. In field trials it stood very well to root rot pressure (tables 1, 2c and 4).

A limited number of plants from this list will be available for trials from Sakuma Bros. in Burlington, WA. Tel.: (360) 757-6611, Ken M. Spooner Farms, Tel.: (253) 845-5717 and from PARC Agassiz (604) 796-1716. You are encouraged to plant and test some of these experimental trial selections.

Table 1. Results summary of the 2007 machine harvesting trial from the Sakuma (S), Hancoop (H) and Janzen (J) planted in 2004, 2005 and 2006 respectively.

Clone	parents	testing location	tested RBDV+[1]	yield (% of meeker)	fruit size (g)	Root rot rating (1=low)	Fruit description	Comments (GT=growers trials)
87-3-37	Cherokee x Tulameen	H 05	*	Low	2.8	1	Round, dark	Harvest well, resistant to Root rot
92-6-41	Chilliwack x 86-41-15	J 06	S	118	4.1	1	dull light red color, small drupelets	GT harvest well suited for processing and fresh market
92-9-39	Malahat x 86-41-15	J 06	S	85	5.0	1.2	dark red high quality glossy	GT harvests well
93-9-48	86-41-25 x Sumner	J 06	*	95	3.9	1.0	IQF type light, FM, firm, light.	Harvest well, stand to root rot.
93-15-37	86-41-25 x Qualicum	J 06	S	113	4.0	1.1	medium dark red color, fine drupelets, firm	GT harvests well, suited for IQF
93-15-38	86-41-25 x Qualicum	J 06	S	85	4.4	1	dark, fine drupelets, firm, high quality	GT harvest well suited for processing and fresh market
93-15-40	86-41-25 x Qualicum	H 05, J 06	-	122	4.7	1.1	light red glossy, round shape, large drupelets	GT harvest well suited for processing and fresh market
96-13R-122	90-20-20 X 86-6-15	H 05	-	low	3.2		Round firm dark glossy	Harvest well,
96-17R-47	90-20-40 x 86-6-16	H 05	-	-	4.0	1.0	Firm, conical, med-red.	Hrvest well, stand well to root rot
96-22R-55	90-21-13 x 87-5-1	J 06	-	90	4.7	1.0	Large dark glossy fruit.	Harvest well
97-30-27	Qualicum x Willamette	J 06	*	low	4.4	-	dark fruit, firm, sweet	Harvest well also IQF type.
1-3-13	Haida x Cowichan	H05 J06	*	high	4~	1.0	Meeker like, productive	Harvest well, vigor plant.
1-30-8	Tulameen x Nootka	J 06	*	85	3.5	1.0	Dark conical, Willamette like	Harvest very well
1-82-3	Kitsilano x Beskid	J 06	-	204	4.4	1.5	Conical long, dark, firm	Harvest well, med size drupes
2-1-32	Cowichan x 86-6-15	H06 J06	*	92	3.9	1.0	Dark, good quality	Harvest very well, stand well to root rot.
2-2-18	Cowichan x Nanoose	H05 J06	*	-	-	1.0	Dark, attractive	Health plant, harvest well.
2-6-16	Cowichan x Moutere	J06	S	80	3.9	1.0	Med red dull firm fruit	Harvest well
2-20-95	Qualicum x Nootka	H 05	*	98	4.5	1.0	dark round Nootka like easy release	harvests well, suited for IQF
3-14-12	Cowichan x Esquimalt	J06	*	110	4.5	1.0	Med red-dark meaty large drupes	Harvest well
3-20-21	Cowichan x 90-19-34	J06	S	-	-	1.0	Small druplets	Harvest well, Root rot resistant

[1] * may be resistant to RBDV because one of it parents is resistant.

Table 2a. Yield, fruit weight, harvest season and harvest ease of raspberry cultivars harvested in 2008, Abbotsford, BC

Clone	Total Yield (kg/hill)	Marketable Yield (tons/ac)	Early Yield[1] (%)	Fruit Weight (g)	5% Harvest (Date)	50% Harvest (Date)	95% Harvest (Date)	Harvest Duration (Days)	ease of harvest (1=Easy 5=hard)
2004 Planting									
BC87-22-18	3.79	6.07	6.4	3.2	14-Jul	27-Jul	16-Aug	34	2.5
BC87-22-8	3.68	5.89	15.8	3.3	11-Jul	24-Jul	17-Aug	38	2.8
BC90-4-23	2.09	3.35	28.8	3.7	10-Jul	18-Jul	22-Jul	13	3.0
BC91-17-11	4.96	7.94	1.1	3.6	17-Jul	31-Jul	19-Aug	34	2.2
BC92-6-41	2.89	4.63	1.9	2.9	16-Jul	25-Jul	08-Aug	24	2.4
BC1-11-10	4.30	6.88	0.5	3.9	18-Jul	02-Aug	19-Aug	33	3.4
BC1-11-12	4.32	6.92	1.4	3.6	17-Jul	27-Jul	10-Aug	25	4.0
BC1-11-15	4.79	7.67	0.0	4.4	18-Jul	31-Jul	18-Aug	32	3.0
BC1-11-5	3.86	6.18	4.0	4.7	15-Jul	27-Jul	16-Aug	33	4.0
BC1-16-8	4.06	6.50	17.3	4.0	10-Jul	21-Jul	02-Aug	24	3.0
BC1-17-1	5.76	9.22	1.7	5.0	17-Jul	29-Jul	14-Aug	29	3.0
BC1-17-4	3.84	6.14	12.7	3.1	12-Jul	22-Jul	07-Aug	27	3.3
BC1-50-2	4.12	6.59	1.1	3.5	16-Jul	27-Jul	10-Aug	26	3.0
BC1-53-41	4.41	7.07	1.6	3.7	16-Jul	29-Jul	17-Aug	33	2.6
BC1-64-8	2.55	4.08	0.0	4.8	29-Jul	10-Aug	24-Aug	27	4.0
BC1-65-39	3.96	6.34	0.0	3.4	22-Jul	05-Aug	22-Aug	32	2.3
BC1-81-2	4.68	7.50	4.8	2.7	14-Jul	29-Jul	17-Aug	35	2.4
BC1-87-38	3.62	5.80	1.7	4.0	16-Jul	27-Jul	09-Aug	25	2.7
BC1-87-7	3.30	5.28	35.8	4.6	10-Jul	18-Jul	31-Jul	22	2.8
BC1-88-6	2.52	4.04	9.9	3.5	12-Jul	23-Jul	06-Aug	26	2.7
C. Bounty	2.95	4.72	35.3	3.5	08-Jul	19-Jul	08-Aug	32	3.4
C. Dawn	3.47	5.57	1.9	2.6	16-Jul	25-Jul	09-Aug	25	2.6
C. Delight	3.97	6.36	0.0	4.9	17-Jul	27-Jul	10-Aug	25	2.8
Chemainus	2.27	3.64	3.8	2.9	15-Jul	27-Jul	14-Aug	31	2.9
Cowichan	3.43	5.49	7.4	4.2	13-Jul	23-Jul	07-Aug	26	2.7
Encore	2.43	3.89	0.0	4.2	16-Jul	27-Jul	10-Aug	26	2.8
Malahat	3.18	5.09	30.2	3.9	07-Jul	20-Jul	11-Aug	36	2.7
Meeker	3.75	6.01	14.0	3.2	11-Jul	23-Jul	07-Aug	28	2.5
Nanoose	3.12	4.99	6.5	5.0	10-Jul	27-Jul	12-Aug	34	2.8
Qualicum	4.05	6.49	6.8	4.3	14-Jul	24-Jul	08-Aug	26	2.5
Saanich	3.96	6.34	1.1	3.0	16-Jul	26-Jul	10-Aug	26	2.8
Tulameen	3.49	5.59	3.0	4.1	15-Jul	27-Jul	12-Aug	29	2.6
Willamette	2.00	3.20	33.5	2.6	07-Jul	18-Jul	01-Aug	26	3.2
LSD[2]	1.66	2.65	14.7	0.8	4	4	9	8	0.9

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 topped to a height of 5ft.

[1]Early Yield harvested before July 16, 2008

[2]Data from replicated plots were subjected to analysis of variance with least significant difference (LSD) of 5% used to separate means

Table 2b. Yield, fruit weight, harvest season and harvest ease of raspberry cultivars and selections harvested in 2008, Abbotsford, BC

Clone	Total Yield (kg/hill)	Marketable Yield (tons/ac)	Early Yield[1] (%)	Fruit Weight (g)	5% Harvest (Date)	50% Harvest (Date)	95% Harvest (Date)	Harvest Duration (Days)	ease of harvest (1=Easy 5=hard)
2005 Planting									
BC90-19-34	2.87	4.60	17.1	3.6	11-Jul	19-Jul	05-Aug	26	2.6
BC92-6-41	3.44	5.51	10.9	3.8	12-Jul	22-Jul	07-Aug	26	2.7
BC93-15-38	2.59	4.15	0.0	4.1	17-Jul	27-Jul	08-Aug	23	2.7
BC93-15-40	4.03	6.45	20.2	4.2	10-Jul	19-Jul	03-Aug	25	2.8
BC93-18-20	3.07	4.92	4.3	3.8	14-Jul	22-Jul	06-Aug	24	2.5
BC96-22R-55	2.74	4.39	0.8	4.7	15-Jul	24-Jul	07-Aug	24	2.6
BC97-27-31	3.95	6.33	32.7	4.1	07-Jul	18-Jul	29-Jul	23	3.0
BC97-27-6	3.06	4.90	52.4	3.6	05-Jul	14-Jul	26-Jul	22	2.6
BC97-33-33	3.97	6.37	0.0	3.6	16-Jul	26-Jul	08-Aug	24	2.5
BC1-21-3	2.87	4.59	14.5	4.0	12-Jul	27-Jul	16-Aug	36	2.7
BC1-87-19	2.52	4.04	21.9	4.3	08-Jul	25-Jul	04-Aug	28	2.8
BC2-1-57	3.36	5.39	15.0	3.8	11-Jul	19-Jul	05-Aug	26	2.6
BC2-20-95	2.30	3.69	45.2	4.1	06-Jul	15-Jul	29-Jul	24	3.2
Chemainus	3.11	4.99	18.5	4.3	09-Jul	20-Jul	05-Aug	28	2.3
Coho	1.70	2.73	0.0	3.8	15-Jul	30-Jul	10-Aug	27	2.3
Cowichan	2.39	3.82	24.7	4.2	09-Jul	18-Jul	03-Aug	26	2.7
Esquimalt	2.55	4.09	8.8	2.2	13-Jul	27-Jul	05-Aug	24	3.2
Malahat	3.48	5.58	36.1	4.5	05-Jul	18-Jul	07-Aug	34	2.6
Meeker	3.83	6.13	7.5	3.1	13-Jul	23-Jul	05-Aug	24	2.8
Moutere	4.01	6.42	27.8	4.6	09-Jul	18-Jul	06-Aug	29	3.2
Nanoose	4.31	6.90	14.0	4.7	11-Jul	26-Jul	16-Aug	37	2.9
Octavia	5.51	8.82	0.0	4.3	20-Jul	01-Aug	20-Aug	32	3.2
Qualicum	3.99	6.39	8.5	4.9	13-Jul	23-Jul	06-Aug	25	2.8
Saanich	5.61	8.98	6.7	3.2	13-Jul	22-Jul	09-Aug	28	3.1
Tulameen	3.42	5.47	4.0	4.7	14-Jul	25-Jul	11-Aug	29	2.8
LSD[4]	1.66	2.65	14.7	0.8	4	4	9	8	0.9

see foot notes on table 1a

Table 2c. Yield, fruit weight, harvest season and harvest ease of raspberry cultivars harvested in 2008, Abbotsford, BC

Clone	Total Yield (kg/hill)	Marketable Yield (tons/ac)	Early Yield[1] (%)	Fruit Weight (g)	5% Harvest (Date)	50% Harvest (Date)	95% Harvest (Date)	Harvest Duration (Days)	Ease of harvest (1=Easy 5=hard)
2006 Planting									
BC90-17-45	3.68	5.89	6.1	2.7	15-Jul	30-Jul	10-Aug	28	3.3
BC92-6-41	2.64	4.23	18.1	3.4	11-Jul	24-Jul	07-Aug	28	2.5
BC93-9-40	2.67	4.28	47.8	3.7	07-Jul	17-Jul	31-Jul	25	2.0
BC93-9-48	3.88	6.21	0.0	3.9	18-Jul	28-Jul	09-Aug	23	2.8
BC96-37-1	5.40	8.64	2.1	3.1	18-Jul	31-Jul	14-Aug	29	3.2
BC97-25-58	2.44	3.91	28.3	3.8	11-Jul	19-Jul	24-Jul	14	2.0
BC97-29-29	3.09	4.95	56.7	3.6	06-Jul	16-Jul	31-Jul	26	2.8
BC97-29-35	3.45	5.53	27.4	4.0	11-Jul	21-Jul	02-Aug	23	2.4
BC97-29-71	2.39	3.83	37.5	3.8	10-Jul	20-Jul	29-Jul	20	3.4
BC97-30-27	1.99	3.19	17.6	4.4	11-Jul	22-Jul	31-Jul	21	2.8
BC97-30-3	2.83	4.53	35.7	3.4	10-Jul	19-Jul	05-Aug	27	2.6
BC97-30-49	2.25	3.61	43.6	4.1	09-Jul	18-Jul	05-Aug	29	2.3
BC1-37-32	5.20	8.33	6.4	4.9	15-Jul	30-Jul	11-Aug	28	2.0
BC1-61-38	4.22	6.75	0.0	4.3	03-Aug	11-Aug	25-Aug	23	5.0
BC1-86-21	3.25	5.20	2.2	4.2	17-Jul	25-Jul	08-Aug	24	3.1
BC1-86-7	3.11	4.98	7.8	4.0	14-Jul	26-Jul	08-Aug	26	3.0
BC2-1-74	4.54	7.28	6.2	3.7	15-Jul	23-Jul	05-Aug	22	2.4
BC2-25-19	3.37	5.40	53.4	3.4	10-Jul	16-Jul	30-Jul	21	2.4
BC2-2-76	4.31	6.90	16.4	6.3	12-Jul	22-Jul	08-Aug	28	3.4
BC2-2-89	2.19	3.51	24.8	5.1	11-Jul	19-Jul	24-Jul	14	2.5
BC2-35-34	5.07	8.12	29.9	4.4	10-Jul	21-Jul	09-Aug	31	3.0
BC2-6-16	3.64	5.82	22.4	3.9	11-Jul	23-Jul	08-Aug	29	2.8
BC3-12-8	3.28	5.25	29.3	3.9	10-Jul	20-Jul	01-Aug	23	3.2
BC3-14-12	4.50	7.22	2.8	4.5	17-Jul	27-Jul	09-Aug	24	2.8
BC3-31-10	3.58	5.73	24.2	5.3	11-Jul	21-Jul	01-Aug	22	3.1
BC3-31-39	3.68	5.89	16.8	4.7	12-Jul	24-Jul	08-Aug	28	2.8
BC3-31-63	3.24	5.18	34.9	5.0	10-Jul	19-Jul	30-Jul	21	2.1
C. Bounty	4.12	6.61	14.2	3.5	11-Jul	24-Jul	08-Aug	29	2.8
C. Dawn	2.76	4.43	43.4	3.3	06-Jul	18-Jul	02-Aug	28	3.6
C. Delight	4.32	6.92	4.7	4.4	17-Jul	27-Jul	09-Aug	24	2.6
Chemainus	3.69	5.91	14.3	3.9	12-Jul	25-Jul	08-Aug	28	2.8
Cowichan	3.24	5.20	33.2	4.4	10-Jul	20-Jul	01-Aug	23	2.3
K-81-6	3.85	6.17	8.0	4.0	14-Jul	25-Jul	09-Aug	27	3.0
Malahat	3.50	5.60	54.7	4.2	04-Jul	15-Jul	02-Aug	30	2.2
Meeker	4.10	6.56	14.3	3.0	12-Jul	25-Jul	07-Aug	27	2.5
Saanich	5.13	8.22	7.0	3.4	15-Jul	25-Jul	09-Aug	26	2.3
Tulameen	3.38	5.41	16.1	4.6	11-Jul	22-Jul	08-Aug	29	2.5
Waimea	3.99	6.40	26.5	3.5	10-Jul	21-Jul	04-Aug	26	2.6
LSD[4]	1.66	2.65	14.7	0.8	4	4	9	8	0.9

see foot notes on table 1a

Project No: New

Title: Efficacy of a phosphite product for controlling raspberry root rot caused by *Phytophthora rubi*

Year Initiated 2009 **Current Year** 2009 **Terminating Year** 2010

Personnel:

Thomas Walters, Small Fruit Horticulture Program, WSU-Mount Vernon NWREC
Debra Inglis, Vegetable Pathology Program, WSU-Mount Vernon NWREC

Justification and Background:

Washington State raspberry production ranks first or second in the nation annually, with an annual crop value of $36-46 million dollars. Berry crops are a strong part of the cultural identity of Washington, and there is ample evidence of the health benefits of berry consumption (Network, 2005; Wrolstad, 2005).

Nearly 10% of the operating budget for raspberry production is dedicated to control of Raspberry root rot (MacConnell and Kangiser, 2007), but this disease nonetheless continues to limit the lifetime of many raspberry plantings. Current control measures include treatment with mefenoxam, use of resistant varieties (Moore, 2004; Moore and Finn, 2007), and planting on hills. Drip line placement can have an effect (Walters and Particka, 2008), as can preplant treatments including solarization and gypsum amendment (Maloney et al., 2005). Phosphorous acid and phosphonate products are moderately effective in controlling raspberry root rot (Bristow and Windom, 1992; Maloney et al., 2005). Timing of phosphonate applications is critical to effective control of late blight on tomato (Inglis, unpublished) and late blight and pink rot on potato (Johnson, Inglis, & Miller, 2004). Timing may also be critical to effective control of raspberry root rot, but optimal timing is unknown.

Objectives:

Determine the efficacy of a labeled phosphonate product in preventing Phytophthora root rot of raspberry under greenhouse conditions. Determine whether this product must be applied prior to infection in order to be effective. If effective, we anticipate following up with field or microplot studies in the future to investigate effects of different application timings.

Procedures:

Tissue culture-propagated raspberry (3-6 months old) plant plugs, will be planted into a 2:1 mix of soil and vermiculite within SC-10 cone-tainers™ (Stuewe and Sons, Inc, Tangent OR) in the greenhouse. Seven treatments will be established. Treatments 1-5 will be inoculated with *P. rubi* (20 ml inoculum per 1000 ml soil mix, as described by (Wilcox, 1989). Treatments 1-6 will be flooded for 48 hr. every two weeks.

1. Foliar treatment with ProPhyt® fungicide (Luxembourg-Pamol, Memphis TN) at 4 pt/A. Up to 4 applications will be made on a biweekly basis beginning the day before planting.
2. Foliar treatment with ProPhyt® at 4 pt/A. Up to two biweekly applications will be made beginning four weeks after planting
3. Drench treatment with ProPhyt® at 4 pt/A, up to 4 biweekly applications beginning the day before planting

4. Drench treatment with a single application of Ridomil Gold (Syngenta, Greensboro NC) at 0.25 pt/1000 ft row the day before planting
5. Non-treated, flooded, inoculated check.
6. Non-treated, flooded, non-inoculated check.
7. Non-treated, non-flooded, non-inoculated check.

There will be five replicates of each treatment arranged in a Randomized Complete Block design. Each replicate will include three plants in individual containers. Experimental setup, conduct and evaluation will follow previously established procedures (Walters et al., 2008). The experiment will be duplicated. Approximately 10 weeks after planting, plants with their roots will be removed from the pots, washed and evaluated. Proportion of diseased roots, root rot severity, and root and shoot dry weights will be recorded. Infected roots will be examined for oospores and other reproductive structures to verify that the infection is caused by *Phytophthora*. Data will be analyzed using analysis of variance, with Fisher's protected LSD test for means separations. Walters' program will be responsible for ordering plants, producing inoculum, and assembling greenhouse materials. Inglis' program will be responsible for root rot evaluations and data analysis. Personnel from both programs will participate in experimental set-up, maintenance and take-down, and in preparing presentations and publications.

A small planting of raspberries for a future experimental field trial on application timing will be established in microplots at WSU-NWREC. If ProPhyt demonstrates efficacy in the greenhouse tests, we will use this planting to evaluate application timing under outdoor conditions.

References:

Bristow, P.R.and G.E. Windom. 1992. The effect of sodium tetrathiocarbonate and fosetyl-Al in controlling phytophthora root rot of red raspberry in the Pacific Northwest. Phytopathology. 82: 1132 (abstr.).

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

Maloney, K., M. Pritts, W. Wilcox, and M.J. Kelly. 2005. Suppression of Phytophthora Root Rot in Red Raspberries with cultural practices and soil ammendments. HortScience. 40: 1790-1795.

Moore, P.P. 2004. 'Cascade Delight' Red Raspberry. HortScience. 39: 185-187.

Moore, P.P.and C.E. Finn. 2007. 'Cascade Bounty' Red Raspberry. HortScience. 42: 393-396.

Network, B.H.B. 2005.

Walters, T.and M. Particka. 2008. Drip Tape Placement Affects Development of Raspberry Root Rot. HortScience. 43: 1160.

Walters, T.W., J.N. Pinkerton, and M. Particka. 2008. Methyl Bromide alternatives for raspberry nurseries (abstract). HortScience. 43: 1252.

Wilcox, W.F. 1989. Identity, virulence and isolation frequency of seven Phytophthora spp. causing root rot of raspberry in New York. Phytopathology. 79: 93-101.

Wrolstad, R.E. 2005. Anthocyanins, Polyphenolics and Antioxidant Properties of Pacific Northwest Berries. 2005 International Berry Health Benefits Symposium, Corvallis OR.

Anticipated Benefits and Information Transfer:

Results will be presented to Washington raspberry growers at field days, grower meetings and at commission meetings. The results will also be incorporated into an extension bulletin on irrigation practices for berry crops in Washington. This knowledge will help growers understand whether Phosphite products could play a role in raspberry root rot control., and could potentially set the stage for future collaborative studies. Better yields and less disease will help berry production remain an economically viable activity in the state, and will contribute to rural economic health.

Budget:

Amount allocated by Commission for previous year: $0 – new proposal

Request for FY 2008-2009

Salaries[1/]	$2,938 $1626
Time-Slip	$1,000
Operations (goods & services)[2/]	$750
Travel	
Projected Needs	
Meetings[3/]	$100
Other[4/]	$100
Equipment	
Employee Benefits-salaried[5/]	$1,146 500
Employee Benefits-Time-slip	$166
Total	**$8,596**

[1/] M. Particka, 0.083 FTE (1 month salary and benefits). B. Gunderson, 0.0415 FTE

[2/] Tissue-cultured plants; culture media and petri dishes

[3/] Travel by Walters/Inglis to grower meetings ($0.505/mile)

[4/] Publication costs

[5/] RA benefits 39%; time-slip 16.6%.

Other support of project:
Approximately 0.5 FTE of a Research Associate is provided to the small fruit horticulture program by the WSU Agricultural Research Center. Likewise, approximately 0.5 FTE of a Research Associate is provided to the vegetable pathology program by the WSU Department of Plant Pathology

A substantial amount of equipment costs for this project (for example, greenhouses, field equipment, balances) are covered by the Agricultural Research Center of Washington State University.

Note: *Budget data provided in "Other support of project" is for informative purposed only, for the commission to understand the scope of the project. This estimated support is not presented as formal cost-sharing and, therefore, does not constitute a cost-share obligation on the part of Washington State University. Moreover, there is no requirement for WSU to document this "Other support of project" as part of any cost-share or matching obligation.*

Project No: New

Title: Cooperative raspberry cultivar development program

Year Initiated 2009 Current Year 2009-2010 Terminating Year Continuing

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

Justification:

The Pacific 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 raspberry, blackberry, and strawberry breeding programs in Corvallis has 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 Pacific Northwest breeding programs in Oregon, Washington, and British Columbia have a long history of cooperation. We exchange parents, seedlings, and ideas and thoroughly test and evaluate each others selections. Cultivars developed by these integrated programs should benefit the entire industry in the Pacific Northwest.

Objectives:

To develop raspberry cultivars for the Pacific Northwest in cooperation with Agriculture and Agri-Food Canada and Washington State University that are high-yielding, machine harvestable, disease/virus resistant and that have superior processed fruit quality (#1 Commission Research Priority). New fresh market raspberry cultivars will be pursued as well (#3 Commission Research 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.

Crosses will be done each year to produce seed. Seedling populations are grown and evaluated in Corvallis, Ore. Selections are made and propagated for testing at the Ore. St. Univ. 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 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 the various nurseries to generate plants for trials.

While not directly related to red raspberry at first glance, our current substantial efforts in black raspberry also have the potential to positively impact red raspberry. While much of this work is very specific to black raspberry, our work on aphid resistance may have applications for red raspberry. We have assembled a collection of black raspberry germplasm from across the eastern US (~150 locations) and are screening each population for resistance to raspberry aphid, which is a major vector for several raspberry viruses. To this point we have identified 4 sources of resistance (South Dakota, Michigan, Maine, Ontario). We 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. If these sources hold up they can relatively easily be moved into red raspberry especially 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 presented to the industry to help them make decisions in their operations.

Budget:

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

Amount allocated by Commission for previous year: $ 5,000

Request for FY 2009-2010

Student labor (GS-2)	$4,000
Operations (goods & services)	500
Travel[1]	500
Other: "Land use charge" ($3500/acre)	2,500
Total	**$7,500**

[1]To attend Lynden meetings (1st week December) to present results and to attend and make presentation at the WSU-Puyallup and/or WSU-Mt. Vernon summer field days.

Other support of project:

See attached form on the current and pending support.

While the USDA-ARS program dates to the 1920s, it took a major step forward when it was developed as the Northwest Center for Small Fruit Research and began hiring new scientists in 1993. This program has ongoing breeding program in red raspberries, blackberries, black raspberries, blueberries, and strawberries. While our program has historically been well funded and we have bred red raspberries and willingly tested selections from Washington and British Columbia with almost no direct Commission financial support, costs have risen in the past three years with no increased budget. The USDA-ARS and the Oregon Blackberry and Raspberry Commission through their support of our cooperator Dr. Bernadine Strik at the North Willamette Station have been the primary supporters of this effort. Due to increased costs it is becoming increasingly difficult to continue all of these activities. While we are doing our best to be efficient we also are asking the industry to help us continue the activities we have done in the past.

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: 2008

Accomplishments:

Our goal is 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. Since our analyses will not be complete until our harvest of primocane fruiting types is done, we cannot point to specific genotypes that are excelling (or failing). However, a few observations can be made. ORUS 1142-1 continues to look promising as an early-ripening, very uniformly shaped and sized floricane raspberry. WSU 1499, which is promising in Washington, is not yet high yielding and is very small fruited in Oregon. ORUS 2786-5 looks outstanding as a fresh market primocane fruiting raspberry; while not certain, I expect it to be named within 1-2 years.

Results:

Crosses were successfully made in spring 2008. A new seedling field was established containing red raspberry (25%) and blackberry (75%) seedlings. A large black raspberry seedling field was established with NW Center for Small Fruit Research funding. As of 15 September, 80 red and black raspberry and blackberry selections had been made, of which 36 were raspberry types. Most of the genotypes listed in Table RY1 were harvested. Because we are evaluating a number of primocane fruiting genotypes our harvest is not yet complete this year. I have included our results for the 2007 season as appendices (Tables RY2-RY5). Complete results of all trials for 2008 will be presented at the Commission Research Reports in December.

While not directly related to red raspberry at first glance, our current efforts in black raspberry have identified resistance to the raspberry aphid in populations from South Dakota, Michigan, Maine, and Ontario. If these sources hold up they can relatively easily be moved into red raspberry especially if there are molecular markers to facilitate identifying genotypes with resistance.

Publications:

Until a new cultivar is released and the notice published in a scientific journal, results from our trial are mostly presented informally in Oregon and Washington Commission reports and oral presentations. Also this work is published in our annual NCCC-22 Small Fruit Research Workers report.

Table RY1. Raspberry genotypes potentially harvested in 2008.

Floricane fruiting		*Black Raspberry*
BC 87-11-33	WSU 1502	ORUS 3032-2
BC 90-04-48	WSU 1539	ORUS 3031-3
BC 90-05-30	Cascade Bounty	ORUS 3030-1
BC 90-08-11	Cascade Dawn	ORUS 3013-2
BC 90-08-20	Coho	ORUS 3013-1
BC 90-11-44	Meeker	ORUS 3012-6
BC 90-19-08	Moutere	ORUS 3012-5
BC 91-17-10	Saanich	ORUS 3012-4
BC 92-5-1	Tulameen	ORUS 3012-2
BC 92-6-41		ORUS 3012-1
BC 96-37-1	*Primocane fruiting*	ORUS 2931-1
ORUS 1025-10	ORUS 1167-2	ORUS 3025-1
ORUS 1040-1	ORUS 1173-2	Pequot
ORUS 1040-10	ORUS 1173R-2	Munger
ORUS 1107R-1	ORUS 1179-2	Explorer (primocane)
ORUS 1142-1	ORUS 2786-1	
ORUS 1149-1	ORUS 2786-2	
ORUS 1149-2	ORUS 2786-3	
ORUS 1179-1	ORUS 2786-4	
OSC 892	ORUS 2786-5	
WSU 991	ORUS 2786-6	
WSU 1226	ORUS 2786-7	
WSU 1253	Caroline	
WSU 1384	Heritage	
WSU 1387	Himbo Top	
WSU 1468	Jaclyn	
WSU 1472	Joan J	
WSU 1499		

Table RY2. Mean yield and berry size for floricane fruiting raspberry genotypes at OSU-NWREC planted in 2004 or 2005. Harvested in 2006-07.

Genotype	Berry size (g)^z	Yield (kg/plant)	Yield (t/a)
2004 planted			
Replicated	*2006-07*	*2006-07*	*2006-07*
2006	4.7 b	3.49	5.03
2007	5.4 a	3.52	5.07
WSU 1226	6.4 a	4.06 a	5.84 a
Cascade Dawn	4.1 c	3.77 a	5.42 a
Tulameen	4.7 b	2.70 b	3.89 b
Non replicated			
Saanich	4.2	3.20	4.19
BC 90-04-48	4.7	2.05	4.26
BC 92-05-1	4.6	2.51	3.74
BC 92-06-41	3.3	1.84	2.20
2005 planted			
Replicated	*2007*	*2007*	*2007*
ORUS 1040-10	4.5 a	6.33 a	9.11 a
Coho	**3.6 b**	**3.29 b**	**4.73 b**
ORUS 1142-1	3.5 b	3.08 b	4.43 b
Meeker	**3.0 c**	**2.36 b**	**3.40 b**
BC 92-6-41	3.3 bc	1.83 b	2.63 b
ORUS 1025-10	3.2 bc	1.33 b	1.92 b
Non replicated			
WSU 1472	3.8	5.24	7.55
WSU 1387	4.9	4.19	6.03
WSU 1384	5.2	3.12	4.49
WSU 991	4.7	3.07	4.41
BC 90-05-30	4.4	3.05	4.39
WSU 1468	4.0	3.02	4.35
BC 87-11-33	3.3	2.80	4.03
WSU 1253	3.8	2.77	3.98
BC 96-37-1	2.8	2.70	3.89
BC 91-17-10	3.4	2.63	3.79
BC 90-19-08	4.0	2.51	3.61
BC 90-11-44	3.5	2.40	3.45
WSU 1499	2.1	1.30	1.87
WSU 1539	3.7	1.01	1.45
BC 90-08-11	4.9	0.96	1.38

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

Project No:

Title: Identifying Root Traits Associated with Root Rot Resistance in Red Raspberry

Year Initiated: 2009 Current Year: 2008-2009 Terminating Year: 2011

Personnel:
Principal Investigators: David Bryla, USDA-ARS Horticultural Crops Research Unit, Corvallis, OR; phone: 541-738-4094; email: david.bryla@ars.usda.gov; and Luis Valenzuela-Estrada, Dept. of Horticulture, Oregon State Univ., Corvallis, OR
Collaborators: Pat Moore and Wendy Hoashi-Erhardt, Dept. of Horticulture and Landscape Architecture, Washington State Univ., Puyallup, WA; and Tom Forge, Agriculture and Agri-Food Canada, Agassiz, British Columbia, Canada

Justification:

Phytophthora root rot is a serious problem for commercial production of red raspberry in the Pacific Northwest. Developing new cultivars with high resistance or tolerance to *Phytophthora* root rot is therefore critical to sustaining profitable production in the region and is a major focus of the WSU raspberry breeding program. Current breeding efforts to identify resistant genotypes screen large number of plants in the greenhouse and field and select those demonstrating high tolerance to the disease (Hoashi-Erhardt et al., 2008). Little is known, however, why certain genotypes exhibit a better response than others under the presence of *Phytophthora*.

In citrus and avocado, root rot tolerance has been associated with the capacity of the plant to regenerate roots that have been lost by infection (Graham, 1990; Menge et al., 1992). Other tolerance traits noted in other crops include: 1) increased suberization (cell wall thickening) of both exodermal and endodermal layers in the fine roots (Estone et al., 2003), 2) higher production of fungitoxic compounds, such as phenolics and phytoalexins (Nicholson & Hammerschmidt, 1992; Hammerschmidt, 1999), and 3) enhanced associations with beneficial soil microorganisms, such as mycorrhizal fungi (Mark and Cassells, 1996; Resendes et al., 2008) and bioprotective bacteria (Ezziyyani et al., 2007). Combination of these traits may lead to root rot resistance even under the most severe disease conditions. *The goal of this project is to identify prominent root traits associated with little or no Phytophthora infection in raspberry so that the traits can be selected and incorporated into breeding material to produce new cultivars with high resistance to Phytophthora root rot.*

Numerous raspberry cultivars are available with a wide range of resistance to *Phytophthora* root rot, although none so far are completely resistant. The commercial standard, 'Meeker', falls somewhere near middle of this range with only mild to moderate resistance to root rot. We will examine the roots of 'Meeker' along with six other cultivars, including 'Summit', which is the most resistant cultivar evaluated in Washington, 'Cascade Bounty' and 'Cascade Delight', also found to have high resistance, 'Tulameen', which is similar to 'Meeker' in resistance but different in its root anatomy (Valenzuela-Estrada, personal observation), and 'Malahat' and 'Saanich', two cultivars highly susceptible to root rot. Detecting differences in root traits among the cultivars may provide unique selection criteria for identifying genetic resistance to *Phytophthora* root rot.

One of the most effective methods to study roots is the use of minirhizotrons (see Appendix 1). Minirhizotrons are basically clear plastic tubes installed near the plants that enable us to monitor root development over time using a miniature digital camera system. The application of this type of system in agricultural research has been described in detail by Brown and Upchurch (1987) and has been used successfully to observe root growth and turnover (death) in a variety of perennial fruit crops, including apple (Wells and Eissenstat, 2001), citrus (Kosola et al., 1995), grape (Comas et al., 2000; Anderson et al., 2003; Bauerle et al., 2007), and peach (Basile et al., 2007; Wells et al., 2002); however, it has never been used in raspberry. We are currently using minirhizotrons with success on blueberry and cranberry in Oregon. The potential advantages of the technique are many. It is nondestructive and, consequently, can be used in small plots where disturbance needs to be minimized. Because the same roots are repeatedly examined, it eliminates spatial variation being confounded with temporal variation and permits high frequency of root examination. Probably the biggest advantage of minirhizotrons is that they provide great information on root morphology and demographics *in situ*, including root diameter, specific birth rates, age structure, age-specific death rate, and root lifespan. Root browning is also visible in the images, which often indicates the presence of phenolic compounds in the roots (Wells et al., 2002). Shortcomings of the technique include: 1) root production and losses can only be indirectly converted to biomass, 2) the plastic walls of the minirhizotrons may cause abnormal root behavior, 3) root death may not always be visually apparent, 4) the initial investment of the camera system is fairly high, and 5) labor costs are high, since it takes and enormous amount of time to analyze the root images. Thus, root samples will also be collected periodically (spring, summer, and fall) by using in-growth cores to estimate standing root biomass (e.g., Basile et al., 2007) and vitality (e.g., Comas et al., 2000), examine microscopic features only visible under high magnification (e.g., Valenzuela-Estrada et al., 2008), and extract and quantify phenolics and other fungitoxins accumulated in the roots.

Additional knowledge gained from this study will include basic information on raspberry's root distribution and growth. A plant's ability to absorb water and nutrients from the soil environment primarily depends on the root system's absorption capacity (i.e., the amount of nutrients or water absorbed per unit mass of root tissue) and development (e.g., the number of roots occupying the soil, root fineness, root:shoot ratio, and root hariness). Preliminary observations reveal that root characteristics vary considerably among raspberry cultivars (e.g., 'Cascade Bounty' produces thicker roots on average than 'Meeker') and these characteristics may vary over the growing season as new roots are produced and older roots are shed. We will examine root characteristics of the cultivars (particularly 'Meeker') in order to predict their inherent effectiveness at acquiring water and nutrients from soil. This information will be used to better predict timing and placement of water and fertilizers during the growing season to optimize growth and production and to make recommendations on the best cultivars for efficient water and nutrient management.

This work will complement raspberry breeding efforts in Washington (P. Moore), Oregon (C. Finn), and British Columbia (C. Kempler) and provide useful information helpful to those studying soil ecology (T. Forge) and irrigation and nutrient management (D. Bryla and T. Walters) of the crop.

Objectives:

The objectives of the proposed study are to investigate morphological and physiological root traits in red raspberry that appear to be involved with increased resistance or tolerance to *Phytophthora* root rot. Specifically, this funding year, we will:

1) Establish a field plot with seven cultivars with varying degrees of resistance to root rot at site with a long history of problems with the disease.
2) Monitor root production and distribution in each cultivar and quantify the incidence of root rot.
3) Characterize morphology and anatomy of each root system and examine infection by mycorrhizal fungi and root rot pathogens.

Procedures:

A field of seven raspberry cultivars, including 'Cascade Bounty', 'Cascade Delight', 'Malahat', 'Meeker', 'Saanich', 'Summit', and 'Tulameen', will be planted at the Washington State University Puyallup Research Center. The site has long history of problems with root rot and is located next to one of Pat Moore's current breeding evaluations. Each cultivar will be planted 2.5 x 10 ft. apart and arranged in a completely random block design with six replicates per cultivar; each plot will consist of three plants per cultivar.

Minirhizotron tubes will be installed (30° off vertical and 6-ft deep) at 1 and 2 ft. from the base of the center plant of each plot, providing information on both the spatial and temporal distribution of roots in the soil. Images of roots that grow along the surface of the tubes will be recorded biweekly (Apr.-Oct.) or monthly (Nov.-Feb.) at 2-inch depth increments and analyzed for root production (length of roots produced since the previous sampling), root longevity (duration of each root from first appearance to disappearance), root diameter, and changes in root color using an interactive PC-based software program (RooTracker, Duke University Phytotron). In-growth cores (1-ft. long x 4-in. diameter) will also be installed near the center of each plot; two cores will be collected per plot in May, July, and September each year. Roots will washed from the cores, measured for length using a root scanner, and dried and weighed to determine biomass and specific root length (Basile et al., 2007). A subsample of fresh roots from each core will also be cleared and stained and examined for cellular characteristics, such as root suberization, mycorrhizal colonization, and incidence of infection by root rot pathogens using light and electron microscopes. Identity of the pathogens will be determined using PCRD (Duncan & Cooke, 2002).

All measurements will continue for at least 3 years, with the third year focusing primarily on the most promising traits found to invoke resistance to root rot. Additional measurements will be made in year 3 to identify chemical or molecular characteristics associated with the traits.

Anticipated Benefits and Information Transfer:

This study will be the first detailed examination of root development under field conditions in red raspberry. We will identify inherent root traits associated with increased resistance to *Phytophthora* root rot, which we will eventually use to develop new cultivars with high resistance to root rot. We will also determine when and where new roots are produced, providing important information for optimizing timing and placement of water and nutrients. Results will be presented at field days and grower meetings in Washington and published in extension bulletins.

Budget:

Amount allocated by Commission for previous year: $-0-
Request for FY 2008-2009

Salaries[1]		$ 6,000
Time-Slip		0
Operations (goods & services)		800
Travel		
Projected Needs[2]		500
Meetings		0
Other	0	
Equipment[3]		1,644
Employee Benefits[4]		3,660
Total		$12,604

[1,4]Salary (0.2 FTE) and benefits (0.61 OPE) are required for a postdoctoral associate (L. Valenzuela-Estrada) to conduct the work on capturing and analyzing root images and for microscopic assessment of the root traits.
[2]Travel for one 3-day trip for Bryla and Valenzuela-Estrada to install the minirhizotron tubes.
[3]For purchase of 84 minirhizotron tubes.

Other support of project:

Plant material will be provided by Sakuma Bros. Nursery and field plots will be maintained by WSU. USDA-ARS will provide a vehicle for travel to and from the field site, supply the camera and computers for the minirhizotron work, and pay for the use of light and electron microscope facilities at OSU. See current and pending support for funding on other crops and projects.

References

Anderson, L.J., L.H. Comas, A.N. Lakso, and D.M. Eissenstat. 2003. Multiple risks factors in root survivorship: a 4-year study in Concord grape. New Phytol. 158:489-501.

Basile, B., D.R. Bryla, M.L. Salsman, J. Marsal, C. Cirillo, R.S. Johnson, and T.M. DeJong. 2007. Growth patterns and morphology of fine roots of size-controlling and invigorating rootstocks. Tree Phys. 27:231-241.

Bauerle, T.L., J.H. Richards, D.R. Smart, and D.M. Eissenstat. 2007. Importance of internal hydraulic redistribution for prolonging the lifespan of roots in dry soil. Plant Cell Environ. 31:177-186.

Brown, D.A. and D.R. Upchurch. 1987. Minirhizotrons: A summary of methods and instruments in current use, p. 15-20. In: H.M. Taylor (ed.). Minirhizotron observation tubes: methods and applications for measuring rhizosphere dynamics. ASA Special Pub. No. 50. ASA-CSSA-SSSA Publ., Madison, Wis.

Comas, L.H., D.M. Eissenstat, and A.N. Lakso. 2000. Assessing root death and root system dynamics in a study of grape canopy pruning. New Phytol. 147:171-178.

Duncan JM and Cooke DEL. 2002. Work on raspberry root rot at the Scottish Crop Research Institute. Acta Hort. 585:271-277.

Estone, D.E., C.A. Peterson, and F. Ma. 2003. Root endodermis and exodermis: Structure, function, and response to the environment. J. Plant Growth Regulation 21:335-351.

Ezziyano, M., M.E. Requena, C. Egea-Gilabert, and M.E. Candela. 2007. Biological control of *Phytophthora* root rot of pepper using *Trichoderma harzianum* and *Streptomyces rochei* in combination. J. Phytopathol. 155:342-349.

Kosola, K.R., D.M. Eissenstat, and J.H. Graham. 1995. Root demography of mature citrus trees; influence of *Phytophthora nicotianae*. Plant Soil 171:283-288.

Graham, J.H. 1990. Evaluation of tolerance of citrus rootstocks to *Phytophthora* root rot in chlamydospore-infested soil. Plant Dis. 74:743-746.

Hammerschmidt, R. 1999. Phytoalexins: what have we learned after 60 years? Ann. Rev. Phytopathol. 37:285-306.

Hoashi-Erhardt, W.K., P.P. Moore, G.E. Windom, and P.R. Bristow. 2008. Field and greenhouse response of red raspberry genotypes to root rot. HortScience 43:1367-1370.

Mark, G.L. and A.C. Cassells. 1996. Genotype dependence in the interaction between *Glomus fistulosum*, *Phytophthora fragariae* and the wild strawberry (*Fragaria vesca*). Plant Soil 185:233-238.

Menge, J.A., F.B. Guillemet, S. Campbell, E. Johnson, and E. Pond. 1992. The performance of rootstocks tolerant of root rot caused by *Phytophthora cinnamomi* under field conditions in Southern California. Proc. 2nd World Avocado Cong., p. 53-59.

Nicholson, R.L. and T.R. Hammerschmidt. 1992. Phenolic compounds in their role in disease resistance. Ann. Rev. Plantpathol. 30:369-389.

Resendes M.L., D.R. Bryla, and D.M. Eissenstat. 2008. Early events in the life of apple roots: variation in root growth rate is linked to mycorrhizal and nonmycorrhizal fungal colonization. Plant Soil (Online First™).

Valenzuela-Estrada, L.R., V. Vera, L. Ruth, and D.M. Eissenstat. 2008. Root anatomy, morphology and longevity among root orders in *Vaccinium corymbosum* (Ericaceae). Am. J. Bot. (In press).

Wells, C.E. and D.M. Eissenstat. 2001. Marked differences in survivorship among apple roots of different diameters. Ecology 82:882-892.

Wells, C.E., D.M. Glenn, and D.M. Eissenstat. 2002. Changes in the risk of fine-root mortality with age: a case study with peach. Am. J. Bot. 89:79-87.