2011 Research Proposals & 2010 Progress Reports

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Summary of Budget Requests

	Amount
Bryla, David	
Identifying Root Traits Associated with Root Rot Resistance in Red Raspberry	$12,267
Burrows, Colleen	
Providing real-time occurrence data for Spotted Wing Drosophila in Western Washington red raspberry utilizing local monitoring	$10,690
Evaluating relationships between current and historical raspberry yield, soil health, and nutrient and irrigation management in raspberries in Northwestern Washington	$9,014
Elling, Axel	
New strategies to control root-lesion nematodes	$7,288
Finn, Chad	
Cooperative raspberry cultivar development program	$5,000
Support of SCRI Proposal "Developing the Genomic Infrastructure for Breeding Improved Black Raspberries"	$1,000
Hebert, Vincent	
Analytical Support for Registration of Azoxystrobin in/on Red Raspberry	$1,000
Karkee, Manoj	
Designing a Mechanical Red Raspberry Pruning System to Reduce Labor Demand	$10,839
Kempler, Chaim	
Red Raspberry Cultivar Development	$8,000
Miller, Timothy	
Postemergence Perennial Weed Buckwheat (Bindweed) Control in Red Raspberries	$4,015
Moore, Patrick	
Red Raspberry Breeding, Genetics and Clone Evaluation	$60,000
Machine Harvesting Evaluation of Raspberry Seedlings	$3,819
Sabiani, Shyam	
Ultraviolet light (UV-C) treatment for control of storage rot and extension of postharvest life of red raspberries	$8,661
Teasdale, Carolyn	
Development of a monitoring and mass trapping program for Raspberry Crown Borer	$3,000
Tanigoshi, Lynell	
Chemical control of spotted wing drosophila, Drosophila suzukii (Matsumura) in western Washington red raspberry, utilizing local monitoring while maximizing pollination, honey bee conservation and phenology between fruit ripening and infestation	$13,077
Zasada, Inga	
Evaluation of Novel Nematicides for Root Lesion Nematode Control in Red Raspberry	$10,817
TOTAL	$168,487

Washington Red Raspberry Commission
Research Priorities for 2011

#1 Priorities

- Develop cultivars that are summer bearing, high yielding, winter hardy, machine-harvestable, disease resistant, virus resistant and have superior processed fruit quality
- Understanding soil ecology and soil borne pathogens and their effects on plant health and crop yields
- Fruit rot including pre harvest, post harvest, and/or shelf life.
- Soil fumigation techniques and alternatives to control soil pathogens, nematodes, and weeds
- Evaluation of the life cycle and management options of the Spotted Wing Drosophila

#2 Priorities

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

#3 Priorities

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

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

Personnel:
Principal Investigators: David Bryla, USDA-ARS Horticultural Crops Research Unit, Corvallis, OR; 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

Reporting Period: October 1, 2009 – September 30, 2010

Goals:

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 numbers of plants in the greenhouse and field and select those demonstrating high tolerance to the disease. Little is known, however, why certain genotypes exhibit a better response than others under the presence of *Phytophthora* spp. 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.

Accomplishments (2009-2010):

1) IN August 2009, we began collecting root images from minirhizotron (clear plastic) tubes installed in a field trail of seven cultivars with varying degrees of resistance to root rot. The images were collected biweekly in 2010 using a specialized digital camera that we insert inside the tubes. The trial is located at the Washington State University Payallup Research Center at a site with a long history of problems with root rot. The cultivars include 'Meeker', which is the industry standard, '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, and 'Malahat' and 'Saanich', two cultivars highly susceptible to root rot.

2) Soil cores were collected from each plot in May 2010 and washed to remove to remove the roots. A subsample of roots were stained and examined under a microscope to assess the fine root anatomy of each cultivar. The remaining roots were freeze-dried to identify pathogens using PCRD (Forge). The anatomical work was targeted to identify suberin deposition (a physiological trait in some plants that inhibits hyphal penetration by soil pathogens such as *Phytophthora*) in the epidermal and exodermal (if it existed) layers of the root cortex. Roots were stained with Sudan Red 7B for observations under a light microscope and stained with Fluorol Yellow 088 for observations under a fluorescent microscope. We also included root samples of 'Marion' blackberry and 'Tayberry', which is a cross between 'Aurora' blackberry and a complex tetraploid raspberry, in the suberin analysis, as both are thought to be completely resistant to *Phytophthora*.

Results:

Not surprisingly, cultivars with the highest resistance to root rot produced the most roots and the deepest root system (Fig. 1). We hypothesize that root rot resistance may be associated with the ability of a cultivar to rapidly replace any roots lost to the disease and/or produce roots deeper in the soil profile where the pathogen is less abundant. Next, we plan to run survival analysis on the data to determine the impact of the pathogen on root turnover. The survival analysis will help us determine if roots of the most resistant cultivars a) live longer in the presence of the disease and/or b) are produced more frequently than those from less resistant cultivars.

Preliminary histochemical observations on first- and second-order roots revealed that 'Summit', the most resistant cultivar to root rot, had less suberin in the root exodermis than 'Marion' blackberry but significantly more suberin than 'Malahat', which is the least resistant cultivar (Fig. 2). As already mentioned, suberin inhibits hyphal penetration by root pathogens. The work is ongoing, but so far, it appears that root rot resistance may be related to suberin deposition in caneberry. If this is the case, the trait could be selected during breeding to increase raspberry resistance to root rot.

Figures:

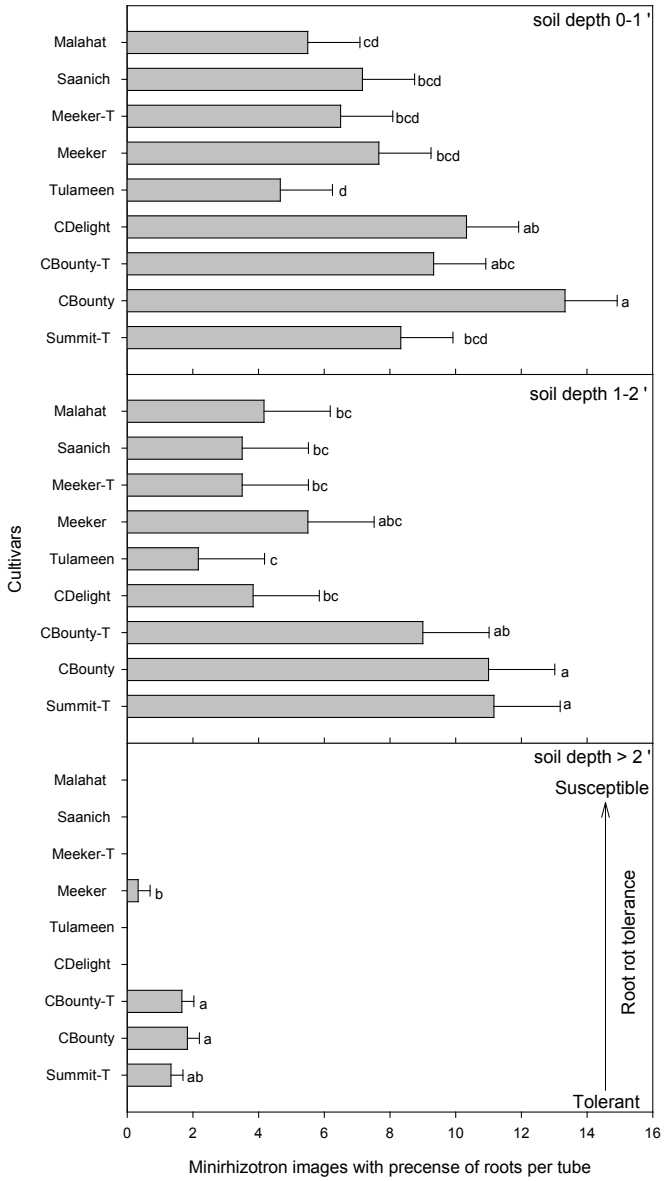

Fig. 1. Mean number of minirhizotron images with roots per tube at 0-1 ft. (top), 1-2 ft. (middle), and >2 ft. (bottom) depth. 'Summit' is considered the most resistant cultivar to phytophthora root rot while 'Malahat' is considered the least resistant cultivar. Different letters next to the bars indicate a significant difference among cultivars.

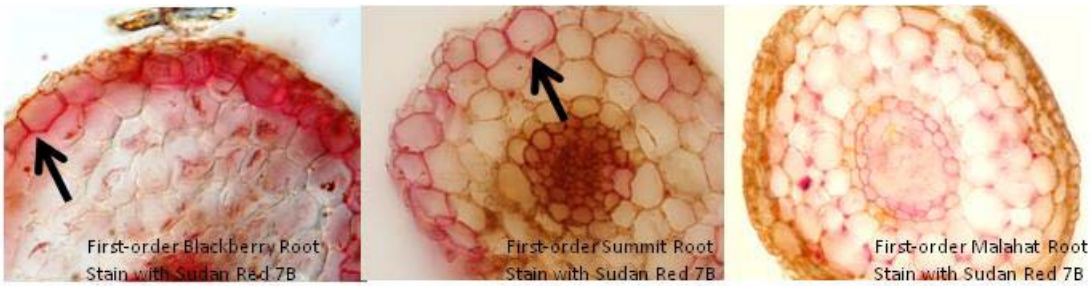

Fig. 2. Cross-sections of 'Marion' blackberry and 'Summit' and 'Malahat' raspberry roots stained with Sudan Red 7B. The images were captured under a light microscope. The black arrows indicate the presence of suberin deposition in the exodermal cell layers of 'Marion' blackberry and 'Summit' raspberry.

Washington Red Raspberry Commission Research Proposal for 2011

COVER SHEET

Application date: November 30, 2010

Name of Applicant Organization/Company

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Principal Investigator

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Co-PI and/or cooperator(s)

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Pat Moore and Wendy Hoashi-Erhardt, Dept. of Horticulture and Landscape Architecture, Washington State Univ., Puyallup, WA

Tom Forge, Agriculture and Agri-Food Canada, Agassiz, British Columbia, Canada

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

Year Initiated 2009 Current Year 2010 Terminating Year 2011

Funding

Total amount requested: $12,267

No other proposals have been submitted for this project. The field plots are maintained by WSU. USDA-ARS covers the following costs: vehicle for travel to and from the field site; the camera system and computers for the minirhizotron work; and the use of microscope facilities at OSU.

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

Year Initiated 2009 Current Year 2010 Terminating Year 2011

Brief description of the project:

The goal of this project is to identify root traits associated with little or no *Phytophthora* infection in raspberry so that the traits can be selected and incorporated into breeding material. In August 2009, we started collecting root images from minirhizotron tubes installed in a field trail of seven cultivars with varying degrees of resistance to root rot. The trial is located at the Washington State University Payallup Research Center at a site with a long history of problems with root rot. We hypothesize that root rot resistance may be associated with the ability of a cultivar to rapidly replace any roots lost to the disease and/or produce roots deeper in the soil profile where the pathogen is less abundant. We also began to examine the roots for evidence of suberin deposition, a physiological trait in some plants that inhibits hyphal penetration by soil pathogens such as *Phytophthora*. The work is ongoing, but so far, it appears that root rot resistance may be related to both rapid root turnover and deposition of suberin in the exodermal layer of the root cortex. If this is the case, the traits could be selected during breeding to increase raspberry resistance to root rot.

Justification and Background:

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 numbers 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; Thomas et al., 2007), 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). A 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 the 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, 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. 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. We are currently using minirhizotrons with success on cranberry and blueberry, and now also on red raspberry. Probably the biggest advantage of the technique

is that it provides a great deal of information on root morphology and demographics *in situ*, including root diameter, root production, root lifespan; root browning, which often indicates the presence of phenolic compounds in the roots (Wells et al., 2002); and root distribution in the soil profile. 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 (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 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, the size and number of root xylem vessels, and root hariness). We will examine root characteristics of the cultivars (particularly 'Meeker') in order to predict their inherent effectiveness at acquiring water and nutrients from soil. The 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.

Our first year results indicate that cultivars with the highest resistance to root rot produced the most roots and the deepest root system (see 2010 Progress Report). The finding suggests that raspberry may tolerate root rot similar to how avocado and citrus cope with it, that is by rapidly regenerating roots lost to infection; however, further data analysis is need to validate the observation. We also have strong evidence that root rot resistance may be related to suberin deposition in caneberry. Further work will help us to identify promising genotypes needed for enhanced selection of the trait.

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.

Relationship to WRRC research priorities:

The research addresses the top two #1 priorities listed by the Commission in 2011, including to: 1) develop disease-resistant cultivars and 2) understand soil ecology and soil-borne pathogens. It also provides basic information on root growth and development, which will be useful for developing better nutrient/irrigation management practices for red raspberry (priority #2).

Objectives:

This is the third year of a 3-year project funded in 2009 by the Commission. The objectives of the project are to investigate root development and morphological and physiological root traits in red raspberry associated with increased resistance or tolerance to *Phytophthora* root rot. Specifically, this funding year, we will:

1) Continue to monitor root production and distribution in each cultivar and quantify the incidence of root rot.
2) Continue to characterize anatomy of each root system and examine infection by mycorrhizal fungi and root rot pathogens.
3) Develop relationships, if any, between the root traits and root rot resistance.

Procedures:

The experiment will continue in a field of seven raspberry cultivars planted in June of 2009, at the Washington State University Puyallup Research Center. The cultivars include 'Cascade Bounty', 'Cascade Delight', 'Malahat', 'Meeker', 'Saanich', 'Summit', and 'Tulameen'. All cultivars were planted from bare root except 'Summit', which was only available from tissue culture. As root development may differ between bare root and tissue culture, 'Meeker' and 'Cascade Bounty' were also

planted from tissue culture for comparison. The field site has a long history of problems with root rot and is located next to Pat Moore's breeding evaluations. Each cultivar was planted 2.5 x 10 ft. apart and arranged in a completely random block design with six replicates per cultivar; each cultivar plot consists of three plants per cultivar.

Roots are monitored using 54 minirhizotron (clear plastic) tubes that were installed (30° off vertical and 6-ft deep) ≈1 ft. from the base of the middle plant of each plot. Images of roots that grow along the surface of the tubes are recorded biweekly (Apr.-Oct.) or monthly (Nov.-Mar.) at 0.6-inch depth increments and are analyzed for root production (number 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 (indicates accumulation of phenolics and other fungitoxic compounds) using an interactive PC-based software program (Win Rhizo-Tron, Regent Instruments, Quebec, Canada).

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. Roots will be washed from the cores, measured for length using a root scanner, and dried and weighed to determine biomass, root tissue density, and specific root length (Basile et al., 2007). A subsample of fresh roots from each core will also be prepared for histochemical measurements and observation under light and fluorescent microscope and examined for cellular characteristics, such as root epidermal and exodermal suberization, mycorrhizal colonization, and incidence of infection by root rot pathogens using light and electron microscopes. Roots will be stained with Sudan Red 7B for observations under a light microscope and stained with Fluorol Yellow 088 for observations under a fluorescent microscope. We will also include root samples of 'Marion' blackberry and 'Tayberry', which is a cross between 'Aurora' blackberry and a complex tetraploid raspberry, in the suberin analysis, as both are thought to be completely resistant to *Phytophthora*. Identity of any *Phytophthora* spp. in the samples will be determined using PCRD (Duncan & Cooke, 2002).

All measurements will continue in 2011, with the third year focusing primarily on the most promising traits found to invoke resistance to root rot. Additional measurements will be made this year to identify chemical or molecular characteristics associated with the traits.

Anticipated Benefits and Information Transfer:

This study is 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.

References:

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 peach rootstocks. Tree Phys. 27:231-241.

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.

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 313:175-186.

Thomas R., X. Fang, K. Ranathunge, T.R. Anderson, C.A. Peterson, and M.A. Bernards. 2007. Soybean root suberin: Anatomical distribution, chemical composition, and relationship to partial resistance to *Phytophthora sojae*. Plant Physiol. 144:299-311.

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. 95:1506-1514.

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.

Budget:

	2009	2010	**2011**
Salaries[1/]	$ 6,000	$ 6,000	$ 6,300
Time-Slip	$ 0	$ 0	$ 0
Operations (goods & services)	$ 800	$ 800	$ 0
Travel[2/]	$ 500	$ 2,124	$ 2,124
Equipment[3/]	$ 1,644	$ 0	$ 0
Benefits[4/]	$ 3,660	$ 3,660	$ 3,843
Total	$12,604*	$12,584*	**$12,267**

Budget Details

[1/]Postdoctoral associate, 0.15 FTE.
[2/]Travel for one to two trips per month (18 trips @ $118 ea.) to the field site for Valenzuela-Estrada.
[3/]For purchase of minirhizotron tubes.
[4/]Benefits 61%.

*Previous funding for project from WRRC.

Application Date: Nov 29, 2010

Name of Applicant Organization:
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Title: Providing real-time occurrence data for Spotted Wing Drosophila in Western Washington red raspberry utilizing local monitoring.

Year initiated: 2010 **Terminating year: 2011**

Funding:
Amount requested: $10,690

Title: Providing real-time occurrence data for Spotted Wing Drosophila in Western Washington red raspberry utilizing local monitoring.

Coordinated scouting of Spotted Wing Drosophila in Western Washington raspberries and immediate data delivery

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

Brief Description of Project:
Spotted Wing Drosophila (SWD) is a new significant direct pest of soft fruit, including red raspberries in Western Washington. This project will scout for first incidence of SWD in grower volunteered fields in several counties in Western Washington. Monitoring will continue throughout the season to determine population dynamics of this pest. Results will be posted anonymously on a public website. Results from individual fields will be emailed to each grower immediately following data collection so that growers can identify need for treatments and treatment efficacy in each of their fields Access to accurate, timely data on SWD populations within a region or a field will allow growers to make efficient treatment decisions. Regular phone conversations will be held with scouts from Western Washington, other parts of Washington, Oregon, and British Columbia to allow for a regional understanding of SWD populations and issues and new technologies around scouting for this pest. This project is part of a larger regional effort to understand the biology and management techniques of SWD.

Justification and Background:

Spotted wing drosophila, *Drosophila suzukii* (Matsumura), Spotted Wing Drosophila (SWD), is a direct pest of red raspberry and has been found in Western Washington soft fruit (including red raspberries, strawberries, and blueberries). Damage from this pest was first found in Western Washington raspberries in late harvests in 2009 and adults and larvae were found in raspberries in 2010, with late harvests especially impacted. Growers need to understand when SWD is becoming prevalent in a field and when it is reproducing and infecting fruit so that they can accurately time treatments.

In 2010, scouting programs were in place in selected regions of Western Washington, utilizing various methods of data collection and information delivery. A coordinated program in Western Washington will give information to growers on what is occurring in fields throughout the region so that growers might be able to predict when population increases may occur in their fields. This coordination will also allow for scouts through the region to communicate with one another on what is working and what is not and for scouting strategies to be adjusted at the same time.

In 2010, growers had little feedback on how their treatments were working, other than by subjective observation on harvested fruit. This project will include weekly inspection of

harvested or harvestable fruit to identify the approximate percent infested fruit in a field, which will assist growers in understanding treatment efficacy.

Relationship to WRRC Research priorities:

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

Objectives:

1. Determine timing of SWD first flight and population increases in red raspberry fields in Western Washington.
2. Identify SWD population trends following first flight and determine fruit infestation levels near harvest time to give growers feedback on treatment efficacy.
3. Provide real-time anonymous scouting information to growers via an area/quadrant based website and personalized emails to grower participants.
4. Coordinate and communicate regularly with scouts in Washington, Oregon, and British Columbia to understand new scouting strategies and how they may be adjusted to enhance grower information.
5. Educate growers on monitoring and management of SWD.

Procedures:

1. *Determine timing of SWD flight in Western Washington*

First incidence of SWD in several counties will be determined by scouts placing multiple traps in fields throughout the region. Between 2 and 5 traps will be placed in each field, depending on field size. Traps will consist of plastic cups containing apple cider vinegar. Other trap types may be tested. Participating farmers will agree to have scouts enter their field weekly to collect data and have the data posted on a public website with data showing trap counts from a county quadrant.

2. *Identify SWD population trends and fruit infestation levels*

Following the initial peak flight detection, fields will continue to be monitored to identify population dynamics within a field and region. From 2010 observations, once fruit begins to ripen, SWD is less attracted to the vinegar traps and more attracted to fruit. Percent infestation of ripe fruit as well as trap counts will be monitored on a weekly basis at participating fields to give growers feedback on efficacy of their treatment program. Scouts will remove 20 fruit per trap location and dissect to inspect for larval presence, recorded as a percentage of infested fruit.

3. *Provide real-time scouting data*

Scouting data will be posted on a website showing weekly counts for each county quadrant or region. Areas will be color coded to indicate trap count levels. Data from fruit infestation studies will be posted in a similar way, allowing growers to observe trap counts in other areas of Western Washington and to estimate timing of population increases.

Personalized data will be emailed to participating growers within 1 day of data collection.

4. *Communication with regional scouts*

We will coordinate weekly or bi-weekly phone calls with scouts within Washington State, Oregon State, and British Columbia to understand SWD trap counts in these regions and new scouting techniques and approaches that may be tested. These calls may also include reports from other scientists working on SWD biology and management.

5. *SWD grower education*

Grower education will include a pre-season meeting in each participating county, outlining research that has been performed in 2010 and informative results. Results from these studies will be available on the WSU Whatcom County, WSU Skagit County, WSU Pierce County, WSU Snohomish County and Peerbolt Crop Management websites. A summary of this work will be presented at the Small Fruit Workshop, held in December in Lynden, WA.

Anticipated Benefits and Information Transfer:

This study will determine the first appearance of SWD for raspberry growers in these counties and give web based information to growers on population dynamics for SWD throughout Western Washington. It will also provide participating growers with immediate feedback on SWD activity at their own fields which they can use to determine efficacy of treatments. Meetings will provide interested growers with further understanding of SWD biology and management.

References:

Oregon State University Extension Publication EM 8991 (October 2009) - A New Pest Attacking Healthy Ripening Fruit in Oregon - Spotted wing Drosophila: *Drosophila suzukii* (Matsumura)

Budget:

	2010
Salaries[1/]	$1,763
Time-Slip[2/]	$4,200
Employee Benefits[3/]	$1,165
Operations (goods and services)[4/]	$500
Travel[5/]	$813
Other	$2,250
Total	**$10,690**

Benefit details:

[1/]One Extension Professional at 0.75% FTE for six months ($1,763)

[2/]Time-slip scouts will be hired in each county of the program. Three hundred hours at $14 per hour (4,200)

[3/]Employee benefits for extension professional at 43.2% ($761.50) and for time slip employees at 9.6% ($403.25)

[4]/Goods and services for the purchasing traps and office supplies ($500)

[5/]Travel for scouts to visit fields and to attend meetings, 1626 miles at $0.50 per mile ($813)

[6/]Other costs. Subcontract with Peerbolt Crop Management to scout in SW Washington ($1,750). Develop computer programming to send automatic emails to growers regarding pest levels ($500)

We have submitted a similar proposal to the Washington State Commission on Pesticide Registration, the Washington Strawberry Commission and the Washington Blueberry Commission for contributions to this project.

Application Date:
November 30, 2010

Name of Applicant Organization:
Washington State University, Pullman, WA, 99164

Principal Investigator:
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Tom Forge, Research Scientist (Soil Ecology) Agriculture and Agri-Food Canada
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Nichole Embertson,Resource Coordinator, Whatcom Conservation District
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Title of Project:
Evaluating relationships between current and historical raspberry yield, soil health, and nutrient and irrigation management in raspberries in Northwestern Washington.

Year Initiated: 2010 **Terminating Year:** 2011

Funding:
Total Amount Requested: $9,014

Title: Evaluating relationships between current and historical raspberry yield, soil health, and nutrient and irrigation management in raspberries in Northwestern Washington.

Brief Description: Red raspberry growers have expressed concerns with yield decline when growing for extended periods on the same land, even with increased fertilization. Red raspberry growers may be wasting money by applying excessive nutrients to the crop or by irrigation practices limiting effectiveness of applied nutrients. Historically, raspberry pathology issues have been studied independently of nutrient and water management; the problems of nutrient leaching and declines in soil health may be linked through soil, nutrient, and water management practices.

The objectives of this project are to collect baseline information to understand how current and historical grower practices relate to yield and soil health factors. Nutrient management practices will be evaluated for correlation to soil health factors. Differences in root lesion nematode populations will be related to farm practices and soil factors. Effects of soil organisms on plant growth will be evaluated.

Relationships between all factors of raspberry production systems will be analyzed to recognize key factors contributing to plant and soil health to guide and justify future research and allow further leveraging of WRRC funds.

A symposium will be held in February to discuss current and future research goals around these topics and develop common future research goals.

Justification and Background: Red raspberry growers have noticed decreased yields over the past 20 years, even with soil fumigation, replanting and increased fertilizer use. One of the suspected contributors to this yield loss is a shift in soil microbial population, perhaps due to an increased dependence on synthetic fertilizer, tillage and declines in soil organic matter.

The tree fruit industry has described similar issues as apple replant disorder, which has been attributed to many factors including high nematode populations, pathogenic fungi and bacteria, and herbicide residues.[i] These factors may also be contributing to the yield reductions seen in red raspberries. Relationships among irrigation practices, fertilization levels, tillage practices, cover cropping, herbicide use, and number of years of continuous red raspberry production in a field may negatively influence soil organic matter and populations of beneficial soil organisms (soil health), leading to buildup of pathogenic soil organisms and reductions in crop yield potential.

Red raspberry growers may be wasting their money by applying excessive nutrients to the crop or by irrigation practices limiting effectiveness of applied nutrients. Evaluating irrigation practices may provide insight into actions that can be taken to increase water use efficiency and decrease time and resources associated with irrigation. Historically, raspberry pathology issues have been studied independently of nutrient and water management; the problems of nutrient leaching and declines in soil health and crop productivity may be linked through soil, nutrient, and water management practices.

This project will develop baseline data on current and historical practices and how they relate to yield and soil health factors. This data will guide future research around these topics to identify agricultural practices that will aid growers in maintaining productive raspberry systems.

Researchers working on issues relating to plant pathology, nutrient management, and water quality may not fully comprehend the overlapping issues and research being done. If several factors influence soil and root health and crop yield as well as water quality issues, these researchers need to understand each other's work and plan how to set up systems research to integrate knowledge to benefit all aspects of the system. The symposium will bring these groups of people together to identify common goals and build relationships for future research.

Relationship to WRRC Research Priorities:
Relationships between soil ecology, soil borne pathogens, and their effects on plant health and crop yields will be investigated. (#1 priority)

Nutrient and irrigation practices will be surveyed to understand relationships of these factors with yield, nitrogen leaching, and soil microbial populations. (#2 priority)

Objectives:

1. To survey current and historical grower practices of fertilizer use, organic matter addition, irrigation practices, and soil management (use of manures/amendments, cover crops, tillage), and to determine how these relate to yield.
2. To evaluate the effect of soil microbial populations on growth of young raspberry plants.
3. To relate nutrient management to soil health factors.
4. To hold a "Soil, Water, and Raspberry Health Symposium" in February, 2011 to bring together regional researchers and interested farmers to discuss current research and future directions for this work.

Procedures: An in-person survey will be performed with 10-15 volunteered and anonymous red raspberry growers in Northwestern Washington to understand the following current and historical information:

- Crop yield trends
- Nutrient use
- Organic matter applications
- Irrigation practices
- Herbicide, fumigant, and fungicide usage
- Tillage and cover crop practices
- Number of years of continuous red raspberry production
- Crop rotations

Each grower will agree to have soil samples collected from at least one field at multiple times during the year to determine root lesion nematode populations, soil organic matter content, post-harvest nutrient levels, and impacts of soil organisms on raspberry growth.

Root lesion nematode populations will be evaluated in soil and root samples collected in the spring and fall; extractions will be made using the Baermann pan and intermittent methods. A composite sample (of 20-30 cores taken) will be evaluated.

Soil organic matter and post-harvest nutrient levels will be measured in soil collected in late September, after nutrient uptake has ended and before fall rains begins. Three locations per field will be sampled with soil cores (depth of 12") taken from both the center of the raised bed and the outside edge of the bed. Samples will be sent to a commercial lab and evaluated for soil organic matter and macro-nutrient levels.[ii]

Soil samples will be collected early in the growing season to determine if factors limiting plant growth are biological in nature. A composite field sample of 3 liters will be taken from each field. Each sample will be divided in half; one half will be steam pasteurized or fumigated and the other half untreated, then split into 4 replications with 3 tissue culture plants grown in each; dry weights of plants will be measured and growth rated subjectively.

Data will be analyzed for correlations between the factors using Pearson's correlation analysis.

A symposium will be held in Mount Vernon in February to bring together regional researchers working on soil, water, and raspberry heath. Researchers will share past, current, and future research around this topic and the group will discuss potential future research to understand relationships between production practices, yield, and water and soil health.

Anticipated Benefits and Information Transfer: Information from the farmer survey, soil sampling, and symposium will be used to demonstrate the range of grower practices and their relationships to soil health factors contributing to crop health and yield. Relationships between nutrient management and soil health will be evaluated to help growers better manage nutrients. Preliminary data will be used to inform areas where further research is warranted in order to leverage grant funding.

Information will be delivered via the WSU Whatcom County Extension website and at the Small Fruit Workshop in December. Individual grower data will be anonymous; relationships between the data points will be disseminated.

[i] Rosenberger, D. Apple Replant Disease. 2008. Rutgers cooperative extension at the New Jersey Agricultural Experiment Station Plant and Pest Advisory, fruit edition. Available at *njaes.rutgers.edu/pubs/plantandpestadvisory/2008/fr0110.pdf*

[ii] Jeffries, M., G. Hughes-Games, M. Sweeney, and C. Mouritzen. 2008. Sustainable Nitrogen Management in British Columbia Raspberry Crops. Acta Hort. 777. 435-438.

Budget:

	2011
Salaries[1/]	$3,761
Time-Slip[2/]	$720
Employee Benefits[3/]	$1,733
Operations (goods and services)[4/]	$1,700
Travel[5/]	$600
Other	$500
Total	**$9,014**

Benefit details:

[1/]One Extension Professional at 0.08% FTE for twelve months ($3,761)

[2/]Time-slip assistance will be used for maintaining greenhouse bioassays and soil sampling: 40 hours at $18 per hour ($720)

[3/]Employee benefits for extension professional at 43.2% ($1,625) and for time slip employees at 15% ($108)

[4]/Goods and services for nematode sampling ($250), soil testing ($1,000), greenhouse space rental ($250), and other field and office supplies ($200). Total ($1,700)

[5/]Travel to growers fields for surveys and soil sampling, 1,200 miles at $0.50 per mile ($600)

[6/]Other costs. Hall rental and refreshments for Symposium ($300). Statistical analysis assistance ($200).

APPLICATION COVER SHEET

Application Date: October 22, 2010

Name of Applicant Organization/Company:
Department of Plant Pathology, Washington State University, P.O. Box 646430, Pullman, WA 99164-6430

Principal Investigator:
Dr. Axel A. Elling, Assistant Professor (Nematology), 509-335-3742, elling@wsu.edu

Title of Project: New strategies to control root-lesion nematodes

Year Initiated: (current year): 2011 **Terminating Year:** 2013 (3 years total)

Funding:
Total amount requested: $7,288 (2011) (estimated $22,065 over three years total)

Other Funding Sources:
Washington Grain Commission, $24,115 7/2010-6/2011

We have applied for funding from the following funding agencies (no funding decisions have been made yet):

Northwest Center for Small Fruits Research, $35,000 (7/2011-6/2012).
Washington Tree Fruit Research Commission, $35,437 (7/2011-6/2012).

Title of Project: New strategies to control root-lesion nematodes

Year Initiated: 2011 Current Year: 2011 Terminating Year: 2013 (3 years total)

Description of Project:
This project is aimed at developing new control strategies against the root-lesion nematode *Pratylenchus penetrans*, which can cause significant damages in raspberries in the Pacific Northwest. Current control strategies strongly depend on synthetic nematicides, but it is likely that the already low number of available products will decrease in the future. Our ultimate goal is to develop raspberry cultivars that are resistant against *P. penetrans*. We propose to exploit a weak link in the infection strategy of *P. penetrans*, namely its dependency on effector genes. The specific objective of the research proposed here is to identify *P. penetrans* effector genes. These genes are active in the salivary glands of *P. penetrans*, from where their products are secreted into host plant tissue during infection. Plant-parasitic nematodes need these secretions to establish themselves as parasites and to survive inside their host plants. We anticipate to build a library of genes that are active in *P. penetrans* salivary glands and to identify *P. penetrans* effector genes in this library as an outcome of this project. Once *P. penetrans* effector genes are identified, their functions can be blocked, which would result in increased resistance of raspberries against root-lesion nematodes.

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

Plant-parasitic nematodes release secretions produced in their salivary glands into their host plants during infection. These secretions degrade plant cell walls, thereby enabling nematode invasion and interfere with the normal functions of host plant physiology. Plant-parasitic nematodes depend on these secretions for their survival and their ability to establish themselves as parasites, which makes these secretions a weak link in their infection strategy and an attractive target for new control methods. Recent studies have shown that disabling the nematode genes (effector genes) that produce these secretions can result in dramatically increased resistance of the host plant (Huang et al. 2006, Sindhu et al. 2009). This can either be achieved through biotechnology or

traditional breeding. However, before the functions of *P. penetrans* effector genes can be disabled to increase plant resistance, the identities of these genes must be known. Whereas significant progress has been made in identifying and disabling effector genes in cyst and root-knot nematodes, information about similar genes in root-lesion nematodes is very limited. Our objective for the project proposed here is to identify effector genes in *P. penetrans*, which can then serve as new control targets.

Relationship to WRRC Research Priorities:
The overall goal of this three-year project is to develop a new control strategy against root-lesion nematodes, which directly addresses the following #1 WRRC priority for 2011: Alternatives to control soil pathogens and nematodes.

Objective:
Build library of genes that are active in *P. penetrans* salivary gland cells and identify effector genes.

Procedures:
We will follow a three-step process to find *P. penetrans* effector genes: (1) collection of salivary gland contents, (2) separation of genes that produce secretions from other genes and (3) identification of effector genes among secretion-producing genes. We expect that the overall project will take three years to complete. The work proposed here is part of a larger project that requires significant funding and is currently being supported (and considered for additional financial support) by a number of funding agencies with an interest in root-lesion nematode control tactics.

We will collect the contents of *P. penetrans* salivary gland cells by using microaspiration equipment available at Washington State University and following established procedures (Gao et al. 2003, Huang et al. 2003). Once we have collected the salivary gland contents of *P. penetrans*, we will use them to produce complementary DNA (cDNA), which represents the message of genes. This will allow us to fuse the obtained salivary gland cell cDNA to known pieces of DNA to create a cDNA library, which serves as a library of genes that are active in *P. penetrans* salivary gland cell regions.

To separate *P. penetrans* genes that produce secretions from other genes, we will sequence the gene library and search for genes that contain a signal peptide-coding region using SignalP software (Bendtsen et al. 2004). The signal peptide region is a hallmark of genes that produce secretions and is therefore present in all effector genes.

Once we have narrowed down the total gene library to those genes that produce secretions, we will isolate effector genes. To this end, we will use a technique, in situ hybridization, which employs a color reaction specific to individual cDNA sequences in question. By using a microscope, we will be able to determine whether the produced pigment is present in *P. penetrans* salivary gland cells. This would indicate that the respective gene is active at that location and therefore a potential effector gene (de Boer et al. 1998).

Timeline:
Collect *P. penetrans* salivary gland contents (7/2011-2/2012); construct cDNA library (2/2012-7/2012); prepare cDNA library for sequencing (8/2012-10/2012); sequencing of cDNA library (11/2012-12/2012); sequence analysis (1/2013-2/2013); in situ hybridizations (3/2013-3/2014); sequence polishing (4/2014-6/2014).

Anticipated Benefits and Information Transfer:
The identification of *P. penetrans* effector genes is important, because once their identities are known, effector genes can be used as control targets. Blocking their functions would result in increased *P. penetrans* resistance. *The research proposed here is important and benefits Washington's raspberry growers, because it aids in developing new nematode control methods that reduce the use of costly nematicides and that provide an alternative control tactic as part of an integrated pest management program.*

We anticipate that our results will be disseminated through presentations at grower meetings and scientific congresses, and through publications in trade magazines and scientific journals.

References:

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

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

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

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

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

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

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

Budget:

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

Budget Details:

[1/]Partial support for an undergraduate student. Depending on outcome of funding decisions about related grant proposals, monies may also be used to partially support a graduate student.
[2/]Travel from Pullman to commission and grower meetings, and to present results at WSU Small Fruits Workshop.
[3/]Benefits 9.6%

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: 2010

Accomplishments:

Our goal is develop raspberry cultivars that either are improvements over the current standards or that will complement them. In addition, the information generated on advanced selections from the WSU and BC programs will be made available and aid in making decisions on the commercial suitability of their materials. If all goes as planned we will release the floricane fruiting ORUS 1142-1 and the primocane fruiting ORUS 2786-5 this coming year. Both are available from the nurseries for commercial trial. ORUS 2786-2 and ORUS 1167-2 are primocane fruiters being cleaned up for trial. ORUS 1167-2 is among the earliest ripening primocane fruiters with a bright attractive fruit. ORUS 1040-1, a floricane fruiter, keeps looking good in our trials. We cannot quite throw it away but it is an old one; it will get cleaned up for commercial trial. WSU 1499 has finally produced a decent sized plant although the yields are not probably high enough. BC 1-88-6 looked interesting for fruit quality and yield in its 1st harvest season. Bit concerned about dusty/dull appearance and flavor. ORUS 3229-1 and ORUS 3234-1 are *Rubus coreanus* derivatives with vigor and hopefully root rot tolerance. Exciting, commercially viable, selections are starting to come out of this species type of background.

Results:

Crosses were successfully made in spring 2010. A new seedling field was established containing red raspberry (25%) and blackberry (75%) seedlings. Twenty-three floricane and primocane fruiting red raspberry selections were made in 2010. In addition, a few selections were made out of raspberry x black raspberry crosses that should be a source of disease resistance in the future. The selections were mostly made as potential cultivars however several are germplasm selections with *R. idaeus* (wild upper Midwest source), *R. innominatus* (glossy, dis. resist, high fruit number/lateral), and *R. crataegifolius* (glossy, dis. resist) in their background We have been working with this germplasm for several generations and it is now nearly cultivar quality. We hope this material will be useful to our program as well as to Pat Moore's and Chaim Kempler's. Table RY1 lists the genotypes that were harvested in 2010 or will be harvested in 2011. Presented in Tables RY2-RY5 are the results from 2010.

While not directly related to red raspberry at first glance, our current efforts in black raspberry have identified raspberry aphid resistance in populations from S. Dakota, Michigan, Maine and Ontario. If these sources hold up they can 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 Commission reports and oral presentations. Also this work is published in our annual NCCC-22 Small Fruit Research Workers report.

Appendices

Table RY1. Red raspberry genotypes in the ground for evaluation in 1010-2011.

Floricane fruiting			*Primocane fruiting*
BC 1-17-1	WSU 1484	Canby	ORUS 979-2
BC 1-37-21	WSU 1499	Cascade Bounty	ORUS 1167-2
BC 1-50-14	WSU 1502	Cascade Dawn	ORUS 2786-2
BC 1-50-2	WSU 1503	Cascade Delight	ORUS 2786-5
BC 1-86-7	WSU 1530	Chemainus	ORUS 3234-2
BC 1-87-9	WSU 1568	Chilliwack	ORUS 3251-1
BC 1-88-6	WSU 1582	Coho	Amity
BC 90-08-11	WSU 1605	Cowichan	Anne
BC 90-08-20	WSU 1629	Lewis	Autumn Bliss
BC 90-11-44	WSU 1713	Malahat	Autumn Britten
BC 90-19-8	WSU 1747	Meeker	Caroline
BC 92-05-47	WSU 1848B	Nanoose	Chinook
BC 93-09-40	WSU 1950	Octavia	Fallgold
BC 93-26-25	WSU 1951	Rudyberry	Goldie (Graton Gold)
BC 97-30-3	WSU 1952	Saanich	Heritage
ORUS 1142-1	WSU 1953	Tulameen	Heritage
ORUS 1040-1	WSU 1954	Ukee	Joan Irene
ORUS 3229-1	WSU 1955	Willamette	Josephine
ORUS 3229-2	WSU 1956		Nantahala
ORUS 3229-3	WSU 1957		Polana
ORUS 3234-1	WSU 1958		Polka
ORUS 3239-1	WSU 1960		Summit
ORUS 3539-1	WSU 1961		
WSU 1206	WSU 991		
WSU 1447			

Table RY2. Mean yield and berry size for floricane fruiting raspberry genotypes at OSU-NWREC planted in 2007. Harvested in 2009-10. No Yr, or GxYr.

Genotype	Berry size (g)[z]	Yield (kg/plant)	Yield (t/a)
Replicated			
Meeker	3.5 b	2.84 a	4.09 a
BC 90-19-8	4.0 a	2.73 a	3.93 a
WSU 1499	2.4 c	1.67 b	2.45 b
WSU 1447	3.5 b	1.70 b	2.41 b
Observation			
Saanich	3.7	3.95	5.69
BC 1-50-14	3.0	2.48	3.57
BC 97-30-3	3.1	2.29	3.30
BC 1-37-21	5.6	2.18	3.13
Chemainus	3.6	2.09	3.01
BC 93-26-25	4.5	1.90	2.74
ORUS 3229-1[y]	2.4	1.51	2.17
WSU 1503	3.0	1.47	2.12
ORUS 3234-1[y]	4.0	1.21	1.75

[z] Mean separation within columns by Duncan's $p \leq 0.05$.
[y] ORUS 3229-1 and ORUS 3234-1 are 1/8 *R. coreanus*

Table RY3. Mean yield and berry size for floricane fruiting red raspberry genotypes at OSU-NWREC planted in 2008. Harvested in 2010.

Genotype	Berry size (g)[z]	Yield (kg/plant)	Yield (t/a)
Replicated			
ORUS 1040-1	3.1 ns	2.95 ns	4.24 ns
Meeker	3.1 ns	2.86 ns	4.11 ns
Observation			
BC 1-88-6	4.2	5.99	8.62
BC 1-17-1	4.7	2.48	3.56
BC 1-50-2	3.5	1.87	2.69
BC 90-8-11	4.0	1.46	2.11
Ukee	2.8	1.36	1.96
BC 93-9-40	3.6	0.75	1.08
BC 90-8-20	3.7	0.57	0.82
BC 1-87-9	4.0	0.50	0.72
BC 90-11-44	3.8	0.41	0.60

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

Table RY4. Mean yield and berry size for primocane fruiting raspberry genotypes at OSU-NWREC planted in 2007 and 2008. Harvested 2008 or 2009 to 2010.

	Berry size (g)	Yield (kg/plt)				Yield (t/a)			
	2008-10	2008	2009	2010	2008-10	2008	2009	2010	2008-10
2007 Planted- Replicated									
2008	2.8 a				0.90 b				1.30
2009	2.6 a				2.26 a				3.25
2010	2.9 a				2.27 a				3.26
ORUS 2786-5	3.2 a	1.48 a	2.48 a	1.74 b	1.90 a	2.13 a	3.57 a	2.50 b	2.73 a
Heritage	2.4 b	0.32 b	2.03 a	2.79 a	1.72 a	0.46 b	2.93 a	4.02 a	2.47 a
2008 Planted- Nonreplicated									
	2009-10		2009	2010	2009-10		2009	2010	2009-10
Polka	2.5	-	3.21	1.95	2.58	-	4.62	2.81	3.72
Polana	2.9	-	2.57	2.01	2.29	-	3.70	2.90	3.30
Heritage	1.8	-	0.60	1.74	1.17	-	0.86	2.51	1.68

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

Table RY5. Mean yield and berry size for primocane fruiting raspberry genotypes at OSU-NWREC planted in 2009.

Genotype	Berry size (g) 2010	Yield (kg/plt) 2010	Yield (t/a) 2010
Replicated			
ORUS 2786-2	2.4 a	1.02 a	1.47 a
Heritage	**1.7 a**	**0.73 a**	**1.05 a**
Nonreplicated			
Summit	1.6	1.73	2.49
Autumn Britten	2.6	1.11	1.60
Caroline	1.5	0.91	1.30
Autumn Bliss	2.6	0.85	1.22
Chinook	2.1	0.78	1.12
Amity	2.0	0.72	1.04
Anne	2.5	0.66	0.94
Graton Gold	1.7	0.29	0.42
Fallgold	1.8	0.26	0.37
Josephine	1.9	0.22	0.32
Nantahala	1.2	0.16	0.23
Joan Irene	3.0	0.13	0.18

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

Table RY6. Ripening season for floricane fruiting red raspberry genotypes at OSU-NWREC. Planted in 2007-08 and harvested 2009-10.

Genotype	Year planted	Harvest season 5%	50%	95%	No. years in mean	Rep/ Obsv.
BC 90-11-44	2008	22-Jun	22-Jun	29-Jun	1	Obsv
BC 1-87-9	2008	22-Jun	29-Jun	29-Jun	1	Obsv
BC 93-9-40	2008	22-Jun	29-Jun	6-Jul	1	Obsv
BC 90-8-20	2008	22-Jun	6-Jul	6-Jul	1	Obsv
BC 97-30-3	2007	22-Jun	6-Jul	13-Jul	2	Obsv
WSU 1499	2007	22-Jun	6-Jul	20-Jul	2	Rep
WSU 1530	2007	26-Jun	6-Jul	13-Jul	2	Obsv
BC 90-19-8	2007	26-Jun	6-Jul	20-Jul	2	Rep
BC 1-37-21	2007	6-Jul	6-Jul	20-Jul	2	Obsv
Chemainus	2007	26-Jun	10-Jul	27-Jul	2	Obsv
BC 93-26-25	2007	29-Jun	10-Jul	13-Jul	2	Obsv
WSU 1447	2007	29-Jun	10-Jul	27-Jul	2	Rep
Ukee	2008	22-Jun	13-Jul	27-Jul	1	Obsv
Meeker	2008	22-Jun	13-Jul	3-Aug	1	Rep
ORUS 1040-1	2008	29-Jun	13-Jul	27-Jul	1	Rep
BC 1-17-1	2008	29-Jun	13-Jul	3-Aug	1	Obsv
BC 1-88-6	2008	29-Jun	13-Jul	3-Aug	1	Obsv
BC 1-50-2	2008	6-Jul	13-Jul	3-Aug	1	Obsv
BC 1-50-14	2007	22-Jun	13-Jul	31-Jul	2	Obsv
Saanich	2007	26-Jun	13-Jul	31-Jul	2	Obsv
Meeker	2007	3-Jul	13-Jul	27-Jul	2	Rep
ORUS 3234-1	2007	3-Jul	17-Jul	24-Jul	2	Obsv
ORUS 3229-1	2007	6-Jul	17-Jul	24-Jul	2	Obsv
BC 90-8-11	2008	6-Jul	20-Jul	3-Aug	1	Obsv

Table RY7. Ripening season for primocane fruiting red raspberry genotypes at OSU-NWREC. Planted in 2007-09 and harvested 2008-10.

Genotype	Year planted	Harvest season 5%	50%	95%	No. years in mean	Rep/ Obsv.
Autumn Bliss	2009	10-Aug	17-Aug	31-Aug	1	Obsv.
Chinook	2009	10-Aug	17-Aug	31-Aug	1	Obsv.
Summit	2009	10-Aug	17-Aug	31-Aug	1	Obsv.
ORUS 2786-2	2009	3-Aug	24-Aug	14-Sep	1	Rep
Amity	2009	10-Aug	24-Aug	7-Sep	1	Obsv.
Autumn Britten	2009	10-Aug	24-Aug	7-Sep	1	Obsv.
Polka	2008	8-Aug	24-Aug	14-Sep	2	Obsv.
Polana	2008	8-Aug	28-Aug	21-Sep	2	Obsv.
Heritage 09	**2009**	**17-Aug**	**31-Aug**	**21-Sep**	**1**	**Rep**
Josephine	2009	24-Aug	31-Aug	7-Sep	1	Obsv.
Anne	2009	24-Aug	31-Aug	14-Sep	1	Obsv.
Caroline	2009	24-Aug	31-Aug	14-Sep	1	Obsv.
Joan Irene	2009	31-Aug	31-Aug	7-Sep	1	Obsv.
Fallgold	2009	24-Aug	7-Sep	7-Sep	1	Obsv.
Graton Gold	2009	31-Aug	7-Sep	7-Sep	1	Obsv.
ORUS 2786-5	2007	18-Aug	10-Sep	5-Oct	3	Rep
Heritage 08	**2008**	**31-Aug**	**11-Sep**	**28-Sep**	**2**	**Obsv**.
Nantahala	2009	14-Sep	28-Sep	5-Oct	1	Obsv.
Heritage 07	**2007**	**8-Sep**	**29-Sep**	**15-Oct**	**3**	**Rep**

APPLICATION COVER SHEET

Application Date: November 5, 2010

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

Principal Investigator:
Chad Finn, Research Geneticist

Title of project:
Cooperative raspberry cultivar development program

Year Initiated (current year) 2011 **Terminating Year Continuing**

Funding

Total amount requested: $5,000

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

I have received significant funding from the USDA-ARS, Northwest Center for Small Fruit Research and the USDA-ARS Plant Exploration Office towards our black raspberry research. We will be applying for a small grant from the North American Raspberry and Blackberry Association for matching funding on a black raspberry grant. While a very different crop, red and black raspberry genetics have a lot in common and we hope that much of what we learn about aphid resistance in black raspberry will carry over to red raspberry.

Title of project: Cooperative raspberry cultivar development program

Year Initiated __2011____ Current Year 2011-2013_ Terminating Year _Continuing__

Brief description of project describing objectives and expected outcome:

The Northwest is the leading berry production region in the world due to a combination of an outstanding location, top notch growers, and a strong history of industry driven research. The USDA-ARS breeding programs have a long history of developing commercially viable cultivars. Cultivars that are high-yielding, machine-harvestable, and that produce high quality fruit are essential for the long term viability of the industry.
Our objectives therefore are:

- To develop cultivars for the Pacific Northwest in cooperation with Agriculture and Agri-Food Canada and Washington State University that are summer bearing high-yielding, winter hardy, machine harvestable, disease and virus resistant and have superior processed fruit quality (#1 Commission Research Priority).

- To develop cultivars using new germplasm that are more vigorous and that may be grown using reduced applications of nutrients and irrigation (#2 Priority).

- New fresh market cultivars will be pursued that provide season extension: improve viability of fresh marketing through floricane or primocane fruiting types (#3 Priority).

We will develop cultivars that are improvements over the current standards or that will complement them. In addition, the information generated on selections from the other breeding programs will aid in making decisions on their commercial suitability.

Justification and Background:

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 have a long history of developing cultivars that are commercially viable. New cultivars that are high yielding, machine harvestable, and that produce very high quality fruit are essential for the long term viability of the industry. Cultivars that replace or complement the current standards, primarily ‘Meeker’ would help towards that goal. Our release, ‘Coho’ was an example of what we are striving for. While ‘Coho’ was initially embraced for its high quality machine harvest product, its susceptibility to root rot prevented it from being widely planted.

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 other’s selections. Cultivars developed by these integrated programs should benefit the entire industry in the Pacific Northwest.

Relationship to WRRC Research priority(s):

Our objectives for raspberry breeding most closely align with a #1 and a #3 Commission Priorities as we are trying to develop cultivars "that are summer bearing high-yielding, winter hardy, machine harvestable, disease and virus resistant and have superior processed fruit quality (#1 Commission Research Priority)" and new fresh market cultivars that provide "season extension: improve viability of fresh marketing" (#3 Priority). In addition, as we work with novel germplasm derived from species other than Rubus idaeus (the primary red raspberry species) and work that into our breeding material we are finding extremely burly, vigorous and disease tolerant selections that should need lower nitrogen and irrigation levels. If we can maintain this vigor as we identify those with commercial fruit quality and yield we ideally would have genotypes that may be grown using reduced applications of nutrients and irrigation which is a #2 Priority.

Objectives:

- To develop cultivars for the Pacific Northwest in cooperation with Agriculture and Agri-Food Canada and Washington State University that are summer bearing high-yielding, winter hardy, machine harvestable, disease and virus resistant and have superior processed fruit quality (#1 Commission Research Priority).

- To develop cultivars using new germplasm that are more vigorous and that may be grown using reduced applications of nutrients and irrigation (#2 Priority).

- New fresh market cultivars will be pursued that provide season extension: improve viability of fresh marketing through floricane or primocane fruiting types (#3 Priority).

Procedures:

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

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

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

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

While not directly related to red raspberry at first glance, our efforts in black raspberry, which are supported by separate funding, have the potential to positively impact red raspberry. While much is specific to black raspberry, our work on aphid resistance should have applications for red raspberry. We have assembled a collection of germplasm from across the eastern US (~150 locations) and have screened each population for resistance to raspberry aphid, which is a major vector for several raspberry viruses. To this point we have identified four sources of resistance and are in the process of studying these sources further and of developing molecular markers that can be used to more efficiently select for this trait in the breeding program. These sources can be moved into red raspberry relatively easily if there are molecular markers to facilitate identifying genotypes with resistance.

Anticipated Benefits and Information Transfer:

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

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

References:

Dossett, M. and C.E. Finn. 2010. Identification of resistance to the large raspberry aphid in black raspberry. J. Amer. Soc. Hort. Sci. 135:438-444.

Finn C.E. and J.F. Hancock. 2008. Raspberries. p. 359-392. In: J. F. Hancock (ed), Temperate fruit crop breeding: Germplasm to genomics. Springer, New York.

Budget:

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

Salaries: Student labor (GS-2)	$2,500
Operations (goods & services)	500
Travel[1]	500
Other: “Land use charge” ($3500/acre)	1,500
Total	**$5,000**

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

Current & Pending Support

Chad Finn

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
Current:					
Finn, C.E.	Fraser Valley Strawberry Growers Association	$2,000	2010	1	USDA-ARS Cooperative Strawberry Breeding Program
Finn, C.E.	Northwest Center for Small Fruit Research	$37,520	2007-2009	5	Breeding blueberry cultivars for the Pacific Northwest
Finn, C.E.	Northwest Center for Small Fruit Research	$8,625	2009-2011	2	Establishment of hardy kiwifruit (*Actinidia arguta*) selection evaluation trial.
Finn, C.E.	Northwest Center for Small Fruit Research	$34,988	2009-2010	5	Molecular markers for aphid resistance in black raspberry
Strik, B.C. and C.E. Finn	Oregon Strawberry Commission	$11,380	2010	2	Cooperative Breeding Program - Strawberries
Strik, B.C. and C.E. Finn	Oregon Raspberry and Blackberry Commission	$10,000	2010	2	Production System/Physiology Research and Cooperative Breeding Program- Raspberries and Blackberries
Rowland, L.J. and 5 team members	USDA Specialty Crop Research Initiative	$1,000,000 (~15K/yr to our program)	2008-2010	5	Generating Genomic Tools for Blueberry Improvement
Tzanetakis, I.E., and 11 team members.	USDA Specialty Crop Research Initiative	$1,463,234 (~7K/yr to our program)	2009-2011	2	Management of virus complexes in *Rubus*.
Iezzoni, A. and 29 team members	USDA Specialty Crop Research Initiative	$7,400,000 (~30K/yr to our program)	2009-2011	5	RosBREED: Enabling marker-assisted breeding in Rosaceae
Finn, C.E.	Washington Blueberry Commission	$7,000	2010	2	Blueberry breeding and cultivar testing in the Pacific Northwest
Finn, C.E.	Washington Red Raspberry Commission	$4,000	2010	2	Cooperative raspberry cultivar development program.
Finn, C.E.	Washington Strawberry Commission	$5,000	2010	2	USDA-ARS Cooperative Strawberry Breeding Program
Pending:					
Finn, C.E.	Fraser Valley Strawberry Growers Association	$2,000	2011		USDA-ARS Cooperative Strawberry Breeding Program
Finn, C.E.	Northwest Center for Small Fruit Research	$4,636	2009-2011	2	Establishment of hardy kiwifruit (*Actinidia arguta*) selection evaluation trial.
Finn, C.E.	Northwest Center for Small Fruit Research	$23,530	2010-2011	4	Evaluation of fruit chemistry traits in wild black raspberry germplasm
Finn, C.E.	Northwest Center for Small Fruit Research	$34,988	2009-2010	5	Molecular markers for aphid resistance in black raspberry
Strik, B.C. and C.E. Finn	Oregon Raspberry and Blackberry Commission	$20,000	2011	2	Production System/Physiology Research and Cooperative Breeding Program- Raspberries and Blackberries
Strik, B.C. and C.E. Finn	Oregon Strawberry Commission	$15,000	2011	2	Cooperative Breeding Program - Strawberries
Finn, C.E.	Washington Blueberry Commission	$7,500	2011	2	Blueberry breeding and cultivar testing in the Pacific Northwest
Finn, C.E.	Washington Red Raspberry Commission	$5,000	2011	2	Cooperative raspberry cultivar development program.
Finn, C.E.	Washington Strawberry Commission	$7,725	2011	2	USDA-ARS Cooperative Strawberry Breeding Program

APPLICATION COVER SHEET

Application Date: November 5, 2010

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

Principal Investigators:
Chad Finn, USDA-ARS Research Geneticist
Nahla Bassil, USDA-ARS Research Geneticist
Jungmin Lee, USDA-ARS Research Chemist

Collaborators:
Courtney Weber, Cornell Univ.
Gina Fernandez, NC State Univ.
Penny Perkins-Veazie, NC State Univ.
Joe Scheerens, Ohio State University
Todd Mockler, Oregon State University
Julie Graham, Scottish Crop Research Institute
Feli Fernandez-Fernandez, East Malling Research
Commercial growers

Title of project:

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

Year Initiated (current year) 2011 Terminating Year 2015

Funding:

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

We will be submitting proposals to the North American Raspberry and Blackberry Association and the Oregon Raspberry and Blackberry Commission for support of this project.

If we are unsuccessful in getting the SCRI grant, we will not need the support from the WRRC

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

Year Initiated __2011_____ Current Year __2011___ Terminating Year _2014__

Brief description of project describing objectives and expected outcome:

The Specialty Crop Research Initiative Grants have become a major source of funding for small fruit research. We will be improving and resubmitting a WRRC supported proposal called "Developing the Genomic Infrastructure for Breeding Improved Black Raspberries", which originally sought $1.16 million in support. **We are only asking for this funding if the grant is funded. If it is not funded we will not need the funding.**

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

How does this tie into red raspberries in Washington? Black raspberries have historically been a source of valuable traits (e.g. disease and insect resistance, fruit firmness) in red raspberry. We expect that a great deal of what we learn will be applicable to red raspberry.

Justification and Background:

The Specialty Crop Research Initiative Grants have become a major source of funding for small fruit research. Last year we submitted a proposal called Developing the Genomic Infrastructure for Breeding Improved Black Raspberries (~$1.16 million) that the WRRC supported in a letter. However since the grant proposal was written in December we were unable to ask for financial support. The grant was not funded as we did not have a strong enough socio-economic and extension component. We plan to respond to the criticism and resubmit the grant in January 2011.Within these grants we are expected to have a 50% match. We have significant commercial and academic matching funding but feel strongly that is important to ask for other funds that while only a small portion of the $620,000 we have in matching shows an industries willingness to contribute.

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

How does this tie into red raspberries in Washington? Black raspberries have historically been a source of valuable traits (e.g. disease and insect resistance, fruit firmness) in red raspberry breeding. We have characterized a great diversity of black raspberry germplasm and most importantly have identified 4 new sources of raspberry aphid resistance. If we can develop markers for traits such as these sources of aphid resistance, we can then fairly easily move them into red raspberry. We expect that a great deal of what we learn will be applicable to red raspberry and objective 5 clearly points to this.

Relationship to WRRC Research priority(s):

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

Objectives:

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

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

Procedures:

I would be delighted to share the detailed procedures with the WRRC if they feel it would be useful. However, I doubt that having the procedures will sway the commission one way or the other on whether they will fund this project.

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

Anticipated Benefits and Information Transfer:

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

Budget:

Repeating myself but want to be clear, we are seeking $1,000/year for this project, however, if the SCRI portion of this project is not funded we will not need any support. We will find out in May 2011 whether or not we were successful.

For each year 2011-2015

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

APPLICATION COVER SHEET

Washington Red Raspberry Commission 2010 Proposal

November 3, 2010

Applicant Organization: WSU-Food and Environmental Quality Laboratory
2710 University Drive, Richland WA 99354

Principal Investigator: Vincent Hebert, Laboratory Research Director
509-372-7393 (phone)
509-205-7389 (cell)
vhebert@tricity.wsu.edu

Project Title: **Analytical Support for Registration of Azoxystrobin in/on Red Raspberry**

Year initiated: June 2011 Terminating year: December 2011

Funding:

Total amount requested: $ 1,000

Pending sources of funding for this project: USDA IR-4 Project; $ 21,036
WSCPR; $ 4,846

Project Title: Analytical Support for Registration of Azoxystrobin in/on Red Raspberry

Year Initiated: 2011 **Current Year**: 2010 **Terminating Year**: 2011

Project Description: The US Environmental Protection Administration (Agency) recently identified GLP *Magnitude of the Residue* data deficiencies for registration of azoxystobin in/on caneberry. The Agency is now requesting more expansive water dispersable granular (WDG) and flowable formulation field trial data to retain the current foliar spray use pattern for this fungicide of 4 to 6 applications spaced at 7-14 day intervals with a 3 day PHI. The WSU-Food and Environmental Laboratory (WSU-FEQL) with pending funding from IR-4 and the WSCPR will perform analytical evaluations to address the above residue data deficiencies for this reduced-risk fungicide.

Justification and Background: Since the cancellation of Benlate, the strobularins (principally, azoxystrobin (Abound^{TM})) have been shown to be an efficacious fungicide class for the treatment of foliar and cane diseases. Foliar treatments with azoxystrobin at cane emergence have been shown to be effective as a disease management tool. This reduced risk fungicide was granted a supplemental label in 2003 for use in red raspberries and other caneberries.

Because of a current residue data deficiency, a complete set of four regional bridging caneberry trials are being planned by the IR-4 Project (OR, NJ, MI, and NC) to support the continued registration of WDG and flowable azoxystrobin formulations. Two of these trials will side-by-side compare WDG and flowable formulation residues. *These bridging studies will support Washington State Abound fungicide use on red raspberry*.

Relationship to WRRC Research Priority(s): # 3; foliar and cane diseases

Objective: The objective is to provide requested residue data to the USEPA through the specialty crop IR-4 Project for the continued registration on Abound in/on red raspberry and for other important PNW caneberries.

Procedures: The WSU-FEQL is a 40 CFR Part 160 GLP testing facility that serves the needs of the PNW specialty crop grower community. Analytical method development, validation, sample analyses, and generation of the summary analytical report for azoxystrobin will be performed at the FEQL Lab. A complete set of four regional bridging field trials are being planned (OR, NJ, MI, and NC) to support caneberry registration WDG and flowable azoxystrobin formulations. Two of these trials will side-by-side compare residues from WDG and flowable formulations.

Residue analyses will be started in October 2011 and should continue through November 2011. We expect to complete the QAU inspected/audited analytical summary report by the end of December 2011 and then forward the report to IR-4 Headquarters for petition preparation.

Anticipated Benefits and Information Transfer: Registration of this fungicide is vitally important to the local rural economies of Washington and PNW states producing red raspberries and blackberries. The potential loss in registration of azoxystrobin would result in the need for Agency guideline data for alternative strobularin class and other fungicides thus causing delays in efficacious products for the grower community.

Budget

Expenditure	**WRRC (Request)**	Co-Funding Funds			TOTAL COST
		****USDA IR-4 (pending)**	**WSCPR (pending)**		
		Amount (CASH)			
Salaries[1]		9,692	4,846		14,538
Employee Benefits[2]		3,344			3,344
Temporary or hourly workers					
Travel					
Equipment					
Supplies	**1,000**	8,000			9,000
Total	**$ 1,000**	$ 21,036	4,846		$ 26,882

CURRENT AND PENDING SUPPORT

Instructions:

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

NAME (List PI #1 first)	SUPPORTING AGENCY AND AGENCY NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Current:				
Brunner J, and Hebert, V.	WSU-Tree Fruit Research Center	$ 59,191	3/09 -6/12	10%	Evaluation of pheromone release from flake and solid matrix dispensers
Hebert, V.	Washington State Potato Commission	$ 71, 670	7/09 – 5/12	10%	Temperature dependence of fumigant emissions with soil temperature
Hebert, V.	Washington State Potato Commission	$ 7,374	7/09 – 5/11	5%	Fumigant Application Efficacy Trials In Light Of Potential EPA Changes
Hebert, V.R. Culbert, E.	USDA IR-4 Project	$ 44,500	5/10 – 6/11	20%	Magnitude of the Residue GLP Specialty Crop Evaluations
Hebert, V.	NOAA Fisheries	$ 17,200	1/10 – 12/10	5%	Verification of insecticide concentrations in juvenile salmon toxicity assessments
	Pending:				
Hebert V.	Washington State Commission of Pesticide Registrations	$ 4,846	1/11 – 12/11	5%	Registration support for azoxystrobin in/on caneberry
Hebert V	USDA IR-4 Project	$ 48,000	6/11 – 5/12	20%	Magnitude of the Residue GLP Specialty Crop Evaluations

APPLICATION COVER SHEET

Application Date: 11/5/2010

Name of Applicant Organization/Company: Washington State University, IAREC, Prosser
24106 N Bunn Rd, Prosser, WA 99350

Principal Investigator: Manoj Karkee, Assistant Professor
Center for Precision and Automated Agricultural Systems, IAREC, Prosser
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Title of Project: **Designing a Mechanical Red Raspberry Pruning System to Reduce Labor Demand**

Year Initiated (current year): 2011 Terminating Year: 2011

Funding:

Total amount requested: **$10,839.00***

* *WSU has funded the PI to purchase equipments such as 3D camera, multi-spectral camera and laptop that can be used to carry out this project. A graduate student is also available to PI with academic year support from WSU. WRRC funding will be used to support the student's summer employment, project related travel and necessary goods and services.*

Additional funding for mechanical pruning system development will be sought from Northwest Center for Small Fruits Research and Washington and Oregon Blueberry Commissions.

Title of Project: **Designing a Mechanical Red Raspberry Pruning System to Reduce Labor Demand**

Year Initiated: **2011** *Current Year:* **2011** *Terminating Year:* **2011**

1. Brief Description of Project:

Pruning is a labor intensive operation in red raspberry production, which constitutes a significant component of total production cost. Mechanization is one of the important ways to reduce labor demand from such labor intensive tasks. This project will focus on designing a system for mechanization of red raspberry pruning. The long term goal of the project is to reduce the use of hand labor in red raspberry production through robotic pruning. The specific objectives are to i) identify pruning rules and methods, ii) develop image processing techniques for pruning, and iii) design robotic end-effecter. These objectives will be achieved through the study of manual pruning operation, analysis of sensor data and design of machine and controller for robotic pruner. This design will provide an opportunity for development and commercialization of autonomous pruning system. Expected outcome is the reduction of hand labor and associated cost in red raspberry production. Reduced labor demand will decrease the risk associated with uncertainty in labor force and increase the long term sustainability of the red raspberry industry. The knowledge acquired through this project will be transferred to stakeholder groups through publications and presentation as well as through social networking media such as Facebook.

2. Justification and Background:

Automation and mechanization is one of the important ways to reduce labor demand in red raspberry production. Researchers working on automation and mechanization area have been primarily focusing on vehicle guidance (Reid et al., 2000; Karkee and Steward, 2010), variable rate application (Maleki, 2008), and mechanical harvesting (Peterson, 2005; Huffman, 2010). Recently, increased amount of federal funding has been available for the research in specialty crop production, primarily through USDA-NIFA Specialty Crop research Initiative (SCRI). Through this grant, federal funding has been allocated for research and development in sensor platform, mechanical thinning, and robotic harvesting, among others (USDA-NIFA-SCRI, 2010). However, the technology for mechanization of pruning operation has still been completely unexplored. Lack of such technology will be a crucial problem for the long term sustainability of red raspberry industry because pruning is a labor intensive operation in red raspberry production (Bolda et al., 2005), which constitutes a significant component of total production cost (MacConnell and Kangiser, 2007).

Our long term goal is to decrease labor demand in red raspberry production through mechanization of pruning operation. The overall objective is to design a software and hardware system for mechanical pruning of red raspberry that takes place during late winter and early spring in Washington farms. It is essential to study the manual pruning of red raspberry and to design an automatic pruning machine so that the design can be used to develop and commercialize an autonomous pruning system. Extensive use of such machine can replace majority of labor force from the pruning operation. Reduced labor demand will

decrease the risk associated with uncertainty in labor force and increase the long term sustainability of the red raspberry industry.

Our team includes engineers with expertise in machine design and automation and a horticulturist with expertise in red raspberry cultural practices. Multi-disciplinary combination of outstanding expertise, access to red raspberry experimental plots at the WSU Mt. Vernon research center and availability of well equipped agricultural automation laboratory at the WSU Center for Precision and Automated Agricultural Systems (CPAAS) makes us particularly well prepared to complete this project successfully. The results from this work will be utilized to develop stronger funding proposals for the next step in automatic pruning system development. We will target funding from relevant commodity groups as well as larger grants from Northwest Center for Small Fruits Research and USDA-NIFA SCRI program.

3. Relationship to WRRC Research Priority(s):

Labor saving through mechanization of red raspberry pruning is a stated research priority of WRRC for 2011 funding cycle. This project fits very well into this priority area.

4. Objectives:

The long term goal of this project is to decrease the labor demand in red raspberry production through the automation and mechanization of pruning operation. Specific objectives are to:

- Identify rules and steps of red raspberry pruning
- Develop an image processing and decision support system for mechanical pruning
- Design and develop computer models of two robotic end-effecters

5. Procedures:

We propose a one year long project to study red raspberry pruning operation and design a system for mechanical pruning. In the first half of this project, manual pruning operation will be studied in the red raspberry experimental plots at Mt. Vernon Research Center and on commercial farms in Skagit and Whatcom counties. This activity will include inspection of plant architectures of the most common varieties and observation of procedures and motions of experienced pruning crews on commercial raspberry farms. In addition, a number of growers and industry engineers from companies such as Oxbo (Korvan) and Littau will be interviewed. Through this investigation, a set of pruning rules and steps that are necessary to mechanize the operation will be identified. A sensor platform will also be developed and images of red raspberry bushes will be collected for laboratory analysis. The sensor platform will include a three dimensional (3D) camera and a color image camera, both to be acquired through WSU funding. A 3D camera directly provides 3D coordinates of the objects in the field of view with respect to a reference coordinate system (Nakarmi and Tang, 2010). This technique reduces the computation burden of other 3D mapping techniques such as stereo-vision and provides opportunity for both day and night time operation.

In the second half, a real-time image and data processing technique will be developed to provide necessary information to mechanical pruner. The pruning rules and steps identified in the first part will be the inputs to this data processing step. The information acquired through 3D camera will be used to develop 3D map of red raspberry bushes. 3D locations and color images will be used complimentarily to identify the canes, laterals and shoots that need to be removed and to find out the respective locations at which these woods need to be removed. An optimal sequence of removal within the predefined neighborhood will also be identified in this step. Performance of the image and data processing technique will be evaluated using the imagery data collected in the first part. In the meantime, two alternative end-effecters and associated actuators and controllers will be designed. Performances of alternative designs will then be evaluated though computer modeling and simulation. 3D locations of the canes and laterals to be removed will be provided as inputs to the simulation study.

6. Anticipated Benefits and Information Transfer:

The output of this project will be software and hardware designs for robotic red raspberry pruning. The designs can be used to develop and commercialize autonomous pruning machines. Extensive use of such machines will reduce hand labor and thus decrease the production cost and increase the long term sustainability of red raspberry industry. The knowledge acquired through this project will be transferred to stakeholder groups and general public through publication of journal articles and presentation in relevant meetings. Extension materials will be developed and communicated through conventional channels as well as the social networking media such as Facebook.

References:

Bolda, M., L. Tourte, K. M. Klonsky and R. L. De Moura, 2005. *Sample cost to produce fresh market raspberry.* University of California Cooperative Extension.

Huffman, W. E., 2010. *The status of labor-saving mechanization in fruits and vegetables.* Conference on Immigration Reform: Implications for Farmers, Farm Workers and Communities. Washington, DC, May 27-28, 2010.

Karkee, M. and B. L. Steward, 2010. *Study of the open and closed loop characteristics of a tractor and a single axle towed implement system.* Journal of Terramechanics, 47(6), 379-393.

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

Maleki, M. R., A. M. Mouazen, B. De Ketelaere, H. Ramon and J. De Baerdemaeker, 2008. *On-the-go variable-rate phosphorus fertilisation based on a visible and near-infrared soil sensor.* Biosystems Engineering, 99(1): 35-46.

Nakarki, A. and L. Tang, 2010. *Inter-plant spacing sensing at early growth stages using a time-of-flight of light based 3D vision sensor.* ASABE, St. Joseph, Michigan, Pub# 1009216.

Peterson, D. L., 2005. *Harvest mechanization progress and prospects for fresh market quality deciduous tree fruits.* Hortechology, 15: 72-75.

Reid, J. F., Q. Zhang, N. Noguchi and M. Dickson, 2000. *Agricultural automatic guidance research in North America.* Computers and Electronics in Agriculture, 25: 155-167.

USDA-NIFA-SCRI, 2010. *Abstract of Currently Funded SCRI Projects: Current Research Information System.* Available at http://cris.nifa.usda.gov, Accessed on Nov 1, 2010.

Budget:

	2011
Salaries	0
Time-Slip[1/]	$ 6,240
Operations (goods and services)[2/]	$ 2,000
Travel[3/]	$ 2,000
Meetings	0
Others	0
Equipment	0
Benefits[4/]	$ 599
Total	$10,839

Budget Details:

[1/] Hourly wage for a graduate student for 13 weeks period during summer 2011 and/or summer 2012

[2/] Cost to build a simple sensor platform

[3/] Travel to northwestern Washington to study the pruning process in red raspberries and to collect sensor data for laboratory processing and testing

[4/] Benefits for the hourly graduate student

Other Support for This Project:

WSU* has funded the PI of this project to purchase equipments such as 3D camera, multi-spectral camera and laptop that can be used to build sensor platform for this project. A graduate student is also available to PI with the academic year support from WSU. WRRC funding will be used to support the student's summer employment and project related travel and necessary goods and services. Additional funding for mechanical pruning system development will be sought from Northwest Center for Small Fruits Research and Washington and Oregon Blueberry Commissions.

**Data provided in the "Other Support for This Project" is for informational purpose only. There is no obligation for cost sharing and WSU dose not provide official documents for this support.*

2010 PROGRESS REPORT

Title: Red Raspberry Cultivar Development for the Pacific Northwest

Personnel: Chaim Kempler, Research Scientist
Brian Harding and Georgia Kliever, Technicians
Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre
PO Box 1000, 6947 #7 Hwy. Agassiz, BC, Canada V0M 1A0
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Summary:
In 2010, PARC selections that were planted on two WRRC machine harvest test sites were evaluated. Yield data from fifty-two plots was collected from these trials planted in 2007 and 2008. The recently released cultivars Ukee and Rudyberry and three advance selections are now propagated and will be available for evaluate in larger plantings on growers' fields. The Saanich and Chemainus cultivars are performing very well; they produce high yields of excellent quality fruit. In the last three years about 1.7 million plants of Chemainus and more than 1.2 million plants of Saanich were planted throughout the PNW.

Accomplishments:
The latest releases from the PARC program performed very well; Chemainus machine harvests very well, producing high quality fruit that is suited for both the fresh and the IQF processing markets. Saanich 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 more than 632 thousand Chemainus plants (1.7 million in the last 3 years) and 288 thousand Saanich plants (1.2 million in the last 3 years) were planted throughout the PNW. Ukee (tested as BC92-6-41) is highly resistant to rot root induced by *Phytophthora fragariae* Var *rubi* and is suitable for machine harvesting, IQF and fresh market sales. Rudyberry (tested as BC90-4-24) produces very high yields of excellent quality fruit that ripen a few days earlier than Meeker.

Over the last three years about 100 of our selections were screened in greenhouse trials for resistance to rot root induced by *Phytophthora fragariae* Var *rubi.* About one third of them were identified as having a good level of resistance, another third had intermediate levels of resistance and the rest were very susceptible. Among the resistant selections BC96-22R-55 and BC3-31-3 were among several that tested as machine harvestable. They are being propagated for advance testing in large plot grower trials. We also identified new sources of resistance derived from *Rubus* species. They will be used as breeding lines.

This year two machine harvest trials were harvested and evaluated. Both were planted at Sakuma Bros. (Mt. Vernon in 2007 and 2008). 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. In 2010 eleven BC selections were planted in the Hancoop machine harvest trial and a further 107 were planted in a new machine harvest trial in Abbotsford. Forty-six new selections were planted in replicated yield and observation plots along with five advanced selections and standard varieties.

During the 2010 harvest season, the 2006 and 2008 plantings were evaluated for yield, fruit traits and harvest season. Harvest data is presented in Tables 2-5. Forty-four selections tested RBDV positive for the first time, and most of them were discarded. One hundred and eighty-eight new selections, mostly from parents combining resistance to RBDV and root rot, were identified from the 2007 crosses. They are being propagated by tissue culture and will then go through root rot screening before being planted yield and machine harvesting evaluation trials in 2011. Twenty-six new crosses were made; the seedlings will go through aphid screening and will be planted in the field for genetic studies that will include sequencing and marker identification. Six thousand seedlings from 2009 crosses were planted and they will be ready for evaluation in 2012.

Notes on cultivars and potential new cultivars:

Chemainus (BC82-5-84 x Tulameen): 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 medium to 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 in production (yield data is presented in the tables).

Saanich [(Algonquin x Chilliwack) x (Nootka x Glen Prosen)]: A promising release from the PARC breeding program that is very productive, producing very high yields with a fruit size that is slightly larger than Meeker and is suited for the fresh or processing markets. The excellent quality fruit are firm with medium gloss, very fine drupelets and a very pleasant sweet flavor associated with low acidity that is comparable to Tulameen. Because of its small drupelet size the fruit IQF's 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. 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 (yield data is presented in the tables).

Ukee (Chilliwack x BC86-41-15): Ukee is a new floricane-fruiting red raspberry cultivar from the PARC breeding program. Ukee produces a high yield of firm large-sized fruit suited for both the fresh and processing markets. It machine harvests very well and is suited for individually quick frozen (IQF). Ukee exhibits an excellent degree of field and greenhouse resistance to root rot caused by *P. rubi*. It is also resistant to the large raspberry aphid, *Amphorophora agathonica*, a vector of the raspberry mosaic virus (RMV) complex. Ukee, tested as BC92-6-41, was selected from a 1992 cross Chilliwack, and selection BC86-41-15. Chilliwack was selected from a cross between BC64-10-198 and Skeena. The other parent, BC 86-41-15, comes from a 2nd back cross from the North American wild raspberry *R. strigosus* (the Dalhousie Lake 4 clone). This clone was collected from Quebec and has a high level of resistance to root rot caused by *P. rubi.* Ukee floricanes are straight and strong. They are thinner than those of Tulameen, Malahat and Chemainus but similar to those of Saanich and Meeker. The canes are noticeably shorter than most other varieties but long enough for use in a 'looped' trellis system. Ukee laterals are long and strong and carry the yield very well; fruit is spread on the laterals and is well presented. The bark is colored cinnamon brown with minimal basal cracking. Spines are also cinnamon brown, 2 mm long, downward pointing and with no basal spot. The spines are plentiful on the lower 40 cm of the cane but reduced in number and length acropetally. Ukee primocanes turn brown to the tip and shed their leaves earlier in the fall than most other varieties. Ukee fruit have an excellent appearance; fruit are medium to large in size and conical with small drupelets. Fruit colour is medium to light red with low gloss and some dusty appearance. Ukee is productive and keeps good fruit size over its long harvesting season. The fruit colour is lighter than that of Meeker; it is acceptable for IQF and possibly for other types of processing where dark pigment is not required. In machine harvest trials Ukee rated as suitable for machine harvesting, giving good fruit quality that is suited for IQF. In IQF trials it appears acceptable, but more testing is needed. The ripening season for Ukee is similar to that of Meeker. Because of its long laterals, Ukee fruit is exposed and therefore easy to hand harvest. The flavour is very good and the fruit size is larger than that of Meeker which makes Ukee very suited for the fresh market. Ukee was selected for resistance conferred by the Ag_1 gene to the common biotype of *A. agathonica*, the N. American large

raspberry aphid vector of the RMV complex, and it has tested negative to RMV ever since the genotype was selected. Ukee first tested positive for RBDV in 2003, five years after it was planted in the field. This delay in getting infected with RBDV suggests that it is moderately tolerant. It has exhibited a high degree of field resistance to root rot caused by *P. rubi* and under extreme root rot pressure at WSU Puyallup it did not show symptoms. While not resistant to spur blight, (*Didymella applanata*), Ukee has been rated as less susceptible than Meeker, Malahat, Chemainus or Tulameen. Ukee, Meeker, Saanich and Malahat have similar (low) susceptibility to cane Botrytis (*B. cinerea*) and show more resistance than Tulameen or Chemainus. Ukee is moderately susceptible to anthracnose (*Elsinoe veneta*), having a response similar to Meeker.

Rudyberry (BC86-41-16 x Qualicum): Rudyberry is a new floricane-fruiting red raspberry cultivar from the PARC breeding program. Rudyberry produces a high yield of firm large-sized fruit that mature early and machine harvest very well and are suited for processing and also for the fresh market. The Rudyberry cultivar exhibits some degree of resistance to root rot caused by *P. rubi*. It is also resistant to the large raspberry aphid, *Amphorophora agathonica*, a vector of the raspberry mosaic virus (RMV) complex. It was named after Mr. Rudy Janzen on whose field this cultivar was tested. Mr. Janzen played an important part in the testing and evaluation processes of the cultivar. Rudyberry tested as BC90-4-23, was selected from a 1990 cross of the PARC released cultivar, Qualicum, and selection BC86-41-15. Qualicum was selected from a cross between the SCRI cultivar Glen Moy and Chilliwack. The other parent, BC 86-41-15, comes from a 2nd back cross from the North American wild raspberry *R. strigosus* (the Dalhousie Lake 4 clone). This clone was collected from Quebec and has a high level of resistance to root rot caused by *P. rubi.*
Rudyberry floricanes are straight and strong and thinner than those of Tulameen, Malahat and Chemainus but similar to those of Saanich and Meeker. When selected in 1994 from a single plant it was noted as early ripening with long laterals, attractive appearance, nice flavor, firm fruit just over 4 g, only a few spines, easy to harvest, medium vigor and potentially resistant to the resistance-breaking biotype of the large raspberry aphid. Rudyberry laterals are long and strong and carry the yield very well; fruit is spread on the laterals and is well presented. The bark is colored light red-brown with no basal cracking. Spines are 3 mm long, downward pointing and with no basal spot. They are a bit longer and thicker than those of Meeker but less abundant on the basal 60 cm, they become reduced in number and length acropetally. Rudyberry fruit have an excellent appearance; fruit are medium to large in size and conical with medium size drupelets. Fruit colour is medium to dark red with high gloss. Rudyberry is productive and maintains a good fruit size over its harvesting season. The fruit colour is similar to that of Meeker; it is acceptable for processing where dark pigment is required. It machine harvests very well with harvest starting a few days before Meeker and ending almost a week before Meeker. Rudyberry was selected for resistance conferred by the Ag_1 gene to the common biotype of *A. agathonica*, the North American large raspberry aphid vector of the RMV complex, and it has tested negative to RMV ever since the genotype was selected. Rudyberry first tested positive for RBDV in 2000, six years after it was planted in the field. It has exhibited some degree of field resistance to root rot caused by *P. rubi.* While not resistant to spur blight, (*Didymella applanata*), Rudyberry has been rated as less susceptible than Meeker, Malahat, Chemainus or Tulameen. Rudyberry, Ukee, Meeker, Saanich and Malahat have similar (low) susceptibility to cane Botrytis (*B. cinerea*) and show more resistance than Tulameen or Chemainus. Rudyberry is moderately susceptible to anthracnose (*Elsinoe veneta*), having a response similar to Meeker. Rudyberry is a multi-purpose cultivar that is suited for machine harvesting/processing and the fresh market. Because it shows some resistance to root rot and is early ripening it may be also suited for the early fresh market as a replacement to the root rot susceptible cultivar Malahat.

New selections for growers' trials:
BC90-8-11 (BC86-41-15 x Qualicum): This is a 2nd backcross from a *R. strigosus* Dalhousie Lake 4 clone. It produces large mid-to-late season crop that is suited for the fresh and processing markets. The fruit is large (5.5 g) and meaty, light red in color, glossy, firm, conical in shape and very attractive. The plant has a good vigor with light green foliage an upright habit and producing enough replacement canes. The fruit is well spaced and presented on the laterals.

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): A productive selection producing mid-size fruit. It originates from a 3rd back cross from the *R. strigosus* the Dalhousie Lake 4 clone. It has performed well in MH trials and has begun testing on larger trials. The fruit is medium size (3.8 g) dark, firm and round shaped with fine drupelets but appears to be not suited for IQF processing but because of its dark color it may be suited as Willamette replacement. The fruit has excellent flavor that is very aromatic and has good acidity. It is not resistant to RBDV but has above average field resistance to root rot. The plant is productive with strong laterals. It produces an earlier crop than Meeker.

BC92-9-15 (Malahat x BC86-41-15): Productive selection that produces large size fruit that matures early and is suited for the fresh and processing markets. This selection stands very well to root rot and machine harvests very well. In machine harvest and fresh market grower trials it was identified as having the potential of replacing Malahat because of its fruit quality, stand against root rot, earliness and machine harvestability. It produces attractive, glossy, medium dark, large, pointed, firm fruit with large drupelets that has good post-harvest quality. It originates from a 3rd back cross from R. strigosus via Skeena, Meeker, Comox and Malahat. It is resistant to aphids but susceptible to spur blight and RBDV.

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 vigour. The harvest season of this selection starts later than Meeker's season and is short and concentrated. In greenhouse trials it tested as highly resistant root rot and also stands very well in several field tests. It tested positive to RBDV in 2009 after more than 10 year of exposure to the virus in the field. It is therefore likely that it will be slow in getting infected.

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 of large fruit that mature a few days earlier than Meeker. The 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.

BC1-61-38 (BC90-19-34 x Glen Magna) Extremely late, finished flowering in late July, fruit ripens into September. It has excellent fruit quality and ripens later and appears more attractive than

Octavia. Fruit is dusty, meaty and firm with an average size of 3 g and very high yields. Canes are thorny. Selection BC1-61-38 may be resistant to root rot.

BC3-14-12 (Cowichan x Esquimalt) Very productive selection suited for the processing and fresh market. It ripens almost a week later than Meeker and produces large fruit with thick meaty walls and is shaped like a barrel. In field trials it stood very well to root rot pressure (Tables 1, 2, 3 and 5).

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

Table 1. Results summary of the machine harvesting trial from the Sakuma (S), Hancoop (H) and Janzen (J) trials

Clone	parents	testing location /year	RBDV+[1] /Root rot	yield (% of meeker)	fruit size (g)	Fruit description	Comments
BC87-3-37	Cherokee x Tulameen	H5	-/R	Low	2.8	Round, dark	Harvest well, resistant to RR.
Ukee	Chilliwack x 86-41-15	H6	+/R	106	3.9	dull light red color, small drupelets	Harvest very well suited for processing IQF and FM.
BC92-5-47	Kitsilano x 86-40-6	S7	+/?	74	3.2	very aromatic good acid, early, dark	Harvest well, not for IQF, Willamette replacement
BC92-9-15	Malahat x 86-41-15	J6	+/R	High		Dark, long pointed large.	Harvest very well, not IQF, FM early.
BC93-9-48	86-41-25 x Sumner	J6	-/R	95	3.9	IQF type light, FM, firm, light.	Harvest well, stand to RR.
BC93-15-38	86-41-25 x Qualicum	S7	+/R	74	4.0	dark, fine drupelets, firm, high quality	harvest well suited for processing and fresh market
BC93-15-40	86-41-25 x Qualicum	H5	-/I	117	4.0	light red glossy, round shape, large drupelets	harvest well suited for processing and fresh market
BC96-13R-122	90-20-20 X 86-6-15	H5	-/?	79	3.1	Round firm dark glossy	Harvest well, IQF, early
BC96-17R-45	90-20-40 x 86-6-15	S7	-/R	-	4	Conical, fine drupes	IQF, Harvest well.
BC96-17R-47	90-20-40 x 86-6-15	H5	-/R	-	4.0	Firm, conical, med-red.	Harvest well, stand well to root rot
BC97-30-3	Qualicum x Willamette	S3 J6 S7	+/I	high	3.7	Conical dusty firm fruit	Harvest well
BC1-3-13	Haida x Cowichan	H5	*/R	high	3	Meeker like, productive	Harvest well, vigor plant.
BC1-86-21	Moutere x Tulameen	S7	-/S	127	4.0	Attractive	Harvest well, attractive
BC1-88-6	Moutere x Saanich	S8	-/		3.9	Conical firm small drupelets	Harvest well
BC2-1-32	Cowichan x 86-6-15	H6	*/R	94	3.9	Dark, good quality	Harvest very well, stand well to root rot.
BC2-2-18	Cowichan x Nanoose	H5	*/I	-	-	Dark, attractive	Health plant, harvest well.
BC2-20-95	Qualicum x Nootka	H5	*/S	105	4.7	dark round Nootka like easy release	harvests well, suited for IQF, very early
BC2-35-34	OPI4	S7	-/S	145	4.0	Light, FM, good quality.	Harvest well, IQF, light.
BC3-14-12	Cowichan x Esquimlut	S7	-/I	high	4.5	Large meaty firm large drupes.	Harvest very well
BC3-31-3	Cowichan x 97-42-21	S7	/R	105	4.0	Meeker like good acid, aromatic	Harvest well, short laterals, productive.

Table 2. Yield and fruit weight of raspberry cultivars and selections from the 2006 planting field, Abbotsford, BC.

Clone	Total Yield (kg/hill)			Fruit Weight (g)			
	2008	2009	2010	2008	2009	2010	Ave.
2006 Planting							
BC90-05-30	3.68	3.05	2.00	2.7	3.8	4.2	3.6
BC93-09-48	3.88	3.38	2.61	3.9	3.7	3.6	3.7
BC96-37-1	5.40	3.32	2.41	3.1	3.1	2.9	3.0
BC97-25-58	2.44	2.81	2.26	3.8	3.5	3.6	3.6
BC97-29-35	3.45	3.03	2.45	4.0	4.3	4.0	4.1
BC97-29-71	2.39	2.60	2.34	3.8	3.1	3.2	3.3
BC97-30-27	1.99	2.28	1.68	4.4	4.0	3.5	3.9
BC97-30-3	2.83	2.60	1.88	3.4	3.3	3.2	3.3
BC1-86-21	3.25	3.19	2.36	4.2	4.0	3.9	4.0
BC2-01-74	4.54	4.49	3.04	3.7	4.6	4.3	4.2
BC2-02-89	2.19	2.69	2.77	5.1	6.0	3.9	5.0
BC2-06-16	3.64	3.13	3.91	3.9	4.2	4.5	4.2
BC3-12-8	3.28	3.08	2.27	3.9	4.5	3.8	4.1
BC3-14-12	4.50	2.58	3.35	4.5	5.9	4.3	4.9
BC3-31-39	3.68	3.51	3.76	4.7	4.0	4.0	4.2
K-81-6	3.85	2.92	1.60	4.0	5.1	4.0	4.4
Cascade Bounty	4.12	3.19	2.54	3.5	2.9	2.7	3.0
Cascade Dawn	2.76	2.15		3.3	3.7		3.5
Cascade Delight	4.32	3.32	3.40	4.4	3.9	3.8	4.0
Chemainus	3.69	3.30	2.80	3.9	3.7	3.7	3.7
Cowichan	3.24	3.47	2.74	4.4	4.6	4.2	4.4
Malahat	3.50	2.03	2.15	4.2	4.3	4.0	4.2
Meeker	4.10	2.52	2.22	3.0	3.0	2.7	2.9
Saanich	5.13	5.08	4.58	3.4	3.1	3.3	3.3
Tulameen	3.38	3.68	2.47	4.6	4.1	4.3	4.3
Ukee	2.64	2.23	1.84	3.4	3.3	3.4	3.4
LSD[1]	1.66	1.35	1.25	0.8	0.9	0.8	0.8
Year Ave.	3.53	3.06	2.62	3.9	4.0	3.7	3.9

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

Table 3. Yield, fruit weight and harvest season of raspberry cultivars and selections planted in 2006 and harvested in 2010 , 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)
BC90-5-30	2.00	3.20	5.9	4.2	03-Jul	13-Jul	31-Jul	29.0
BC90-12-50	2.11	3.37	1.3	3.4	11-Jul	20-Jul	04-Aug	25.0
BC93-9-48	2.61	4.18	0.0	3.6	09-Jul	22-Jul	05-Aug	28.0
BC96-37-1	2.41	3.86	0.0	2.9	09-Jul	26-Jul	09-Aug	32.0
BC97-25-58	2.26	3.62	2.8	3.6	07-Jul	16-Jul	28-Jul	22.0
BC97-29-35	2.45	3.93	3.6	4.0	06-Jul	19-Jul	05-Aug	30.7
BC1-16-8	3.61	5.78	1.7	4.9	07-Jul	14-Jul	04-Aug	29.0
BC1-25-15	2.57	4.11	0.0	5.4	14-Jul	27-Jul	10-Aug	28.0
BC1-50-14	2.21	3.55	1.1	3.0	08-Jul	19-Jul	05-Aug	29.0
BC1-86-21	2.36	3.77	0.0	3.9	08-Jul	21-Jul	06-Aug	29.5
BC1-88-14	2.67	4.27	2.4	2.8	07-Jul	18-Jul	04-Aug	29.0
BC2-1-74	3.04	4.87	0.4	4.3	08-Jul	19-Jul	02-Aug	26.5
BC2-2-89	2.77	4.43	5.9	3.9	06-Jul	14-Jul	28-Jul	23.0
BC2-6-16	3.91	6.26	1.7	4.5	07-Jul	19-Jul	04-Aug	29.0
BC2-6-52	1.98	3.17	0.0	3.4	08-Jul	17-Jul	30-Jul	23.0
BC2-17-21	2.67	4.27	2.1	4.4	07-Jul	22-Jul	04-Aug	29.0
BC2-18-49	2.30	3.68	22.2	3.1	27-Jun	12-Jul	26-Jul	30.0
BC2-30-22	1.39	2.23	5.3	4.7	06-Jul	12-Jul	26-Jul	21.0
BC2-35-34	2.32	3.72	4.3	4.0	14-Jul	22-Jul	06-Aug	24.0
BC3-10-15	2.84	4.55	0.0	3.1	12-Jul	24-Jul	07-Aug	26.5
BC3-12-6	2.08	3.33	0.0	3.2	11-Jul	24-Jul	10-Aug	31.0
BC3-14-12	3.35	5.37	0.0	4.3	10-Jul	22-Jul	06-Aug	28.0
BC3-14-43	2.65	4.25	0.0	4.7	09-Jul	22-Jul	07-Aug	30.0
BC3-16-16	3.96	6.34	0.5	3.2	08-Jul	20-Jul	05-Aug	29.0
BC3-22-29	2.40	3.84	0.0	3.1	12-Jul	24-Jul	07-Aug	26.7
BC3-29-10	2.09	3.34	0.0	3.6	07-Jul	16-Jul	01-Aug	26.0
BC3-31-10	3.11	4.98	0.5	4.7	09-Jul	24-Jul	08-Aug	31.5
BC3-31-3	2.31	3.71	2.6	3.7	07-Jul	18-Jul	03-Aug	28.0
BC3-31-39	3.76	6.03	0.0	4.0	17-Jul	31-Jul	10-Aug	25.0
BC3-31-43	2.61	4.19	1.8	3.8	07-Jul	19-Jul	05-Aug	30.0
BC3-31-63	3.53	5.66	5.0	4.7	06-Jul	20-Jul	02-Aug	28.0
BC3-31-8	3.01	4.82	2.6	4.6	07-Jul	19-Jul	05-Aug	30.0
BC3-31-9	2.40	3.84	3.8	3.6	07-Jul	20-Jul	04-Aug	29.0
WSU 1447	1.62	2.59	7.8	3.8	05-Jul	13-Jul	27-Jul	23.0
Cascade Delight	3.40	5.44	0.3	3.8	09-Jul	22-Jul	03-Aug	26.5
Cascade Bounty	2.54	4.06	2.5	2.7	07-Jul	19-Jul	03-Aug	28.0
Chemainus	2.80	4.48	1.0	3.7	08-Jul	22-Jul	07-Aug	30.7
Cowichan	2.74	4.39	2.1	4.2	07-Jul	17-Jul	01-Aug	26.0
K-81-6	1.60	2.56	2.0	4.0	08-Jul	22-Jul	08-Aug	32.0
Malahat	2.15	3.44	5.6	4.0	06-Jul	20-Jul	08-Aug	34.0
Meeker	2.22	3.55	0.3	2.7	09-Jul	22-Jul	04-Aug	27.3
Rudyberry	3.01	4.82	5.4	4.0	02-Jul	13-Jul	01-Aug	31.0
Saanich	4.58	7.33	1.2	3.3	08-Jul	20-Jul	04-Aug	28.0
Tulameen	2.47	3.95	3.2	4.3	07-Jul	20-Jul	06-Aug	31.0
Ukee	1.84	2.95	2.6	3.4	09-Jul	19-Jul	31-Jul	23.3
Mean	2.64	4.22		3.8				
LSD[2]	1.25	2.00	7.7	0.8	5.0	3.8	4.8	5.9

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 6, 2008

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

Table 4. Yield, fruit weight, harvest season and harvest ease of raspberry cultivars planted in 2008 and harvested in 2010, 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)
2008 Planting								
BC90-5-30	2.68	4.30	15.6	4.3	01-Jul	14-Jul	03-Aug	33.7
BC92-5-47	3.05	4.89	6.3	4.2	06-Jul	17-Jul	03-Aug	29.0
BC96-17R-45	2.54	4.07	0.0	3.8	07-Jul	18-Jul	31-Jul	25.0
BC1-17-1	4.00	6.41	6.5	4.8	05-Jul	17-Jul	03-Aug	30.7
BC1-37-4	3.67	5.87	32.5	3.9	30-Jun	11-Jul	26-Jul	27.0
BC1-39-6	1.33	2.13	29.2	3.7	28-Jun	10-Jul	24-Jul	26.5
BC1-67-24	3.78	6.06	3.7	4.0	08-Jul	19-Jul	03-Aug	27.5
BC1-88-6	4.18	6.69	4.4	4.7	07-Jul	18-Jul	03-Aug	27.7
BC3-11-7	3.36	5.39	6.4	4.3	06-Jul	16-Jul	31-Jul	26.0
BC3-19-8	1.70	2.72	28.6	3.2	30-Jun	10-Jul	24-Jul	25.0
BC4-13-46	2.40	3.84	2.5	4.3	08-Jul	17-Jul	06-Aug	30.0
BC4-13-7	2.98	4.77	19.1	5.1	01-Jul	12-Jul	29-Jul	29.3
BC4-17-3	3.90	6.24	2.6	3.5	09-Jul	20-Jul	07-Aug	30.0
BC4-22-91	2.67	4.28	1.0	2.9	09-Jul	18-Jul	02-Aug	25.0
BC4-33-9	3.25	5.20	0.0	2.8	14-Jul	26-Jul	08-Aug	26.0
BC4-36-17	2.70	4.33	6.6	3.3	05-Jul	16-Jul	31-Jul	27.0
BC4-4-11	2.68	4.30	3.4	4.6	08-Jul	15-Jul	30-Jul	23.0
BC4-41-11	2.83	4.54	71.8	3.6	23-Jun	02-Jul	21-Jul	29.0
BC4-41-8	4.39	7.03	12.0	4.2	02-Jul	15-Jul	01-Aug	31.0
BC4-41-87	2.76	4.42	1.1	4.7	08-Jul	15-Jul	30-Jul	23.0
BC4-42-59	3.54	5.67	5.4	4.2	07-Jul	17-Jul	01-Aug	26.3
BC4-42-76	2.84	4.54	2.9	4.2	08-Jul	18-Jul	03-Aug	27.0
BC4-46-59	3.18	5.09	1.0	3.9	08-Jul	15-Jul	04-Aug	28.0
BC4-65-3	3.36	5.38	0.0	2.8	15-Jul	28-Jul	08-Aug	25.0
BC4-66-16	2.62	4.20	4.6	3.9	08-Jul	18-Jul	03-Aug	27.0
BC4-67-3	2.71	4.35	15.1	3.0	01-Jul	15-Jul	03-Aug	34.0
BC4-9-17	4.76	7.62	0.0	5.9	13-Jul	25-Jul	09-Aug	28.0
BC4-93-2	3.56	5.70	3.7	5.1	08-Jul	16-Jul	29-Jul	22.7
WSU 1447	2.60	4.16	10.4	3.4	03-Jul	14-Jul	01-Aug	29.7
WSU 1499	2.56	4.10	12.2	2.3	02-Jul	15-Jul	01-Aug	31.0
WSU 1502	1.05	1.68	8.6	2.7	04-Jul	12-Jul	19-Jul	16.0
C. Bounty	3.06	4.91	6.5	3.1	05-Jul	17-Jul	03-Aug	29.7
Chemainus	3.63	5.82	2.6	3.6	09-Jul	21-Jul	05-Aug	28.5
Jeanne d'Orleans	2.83	4.53	0.0	3.2	12-Jul	23-Jul	05-Aug	25.0
Malahat	3.14	5.02	18.5	4.0	01-Jul	15-Jul	02-Aug	33.0
Meeker	3.67	5.87	1.1	3.1	10-Jul	20-Jul	03-Aug	25.7
Saanich	5.03	8.06	1.9	3.4	09-Jul	21-Jul	06-Aug	29.0
Tulameen	2.94	4.72	0.5	4.1	10-Jul	23-Jul	06-Aug	28.0
Mean	3.10	4.97		3.83				
LSD[4]	1.25	2.00	7.7	0.8	5.0	3.8	4.8	5.9

see foot notes on table 3

Table 5. Fruit traits of raspberry cultivars and selections harvested in 2010, Abbotsford, BC.

Clone	Soluble Solids Concentration (%)	Firmness-diameter (g/cm2)	Firmness-length (g/cm2)	Firmness (g/cm2)	Fruit Diameter (mm)	Fruit Length (mm)	L/D Ratio
BC90-5-30	11.5	49.0	39.5	44.2	20.4	26.0	1.27
BC97-29-35	11.1	45.2	29.8	37.5	18.6	26.3	1.42
BC1-17-1	11.4	45.8	31.7	38.8	21.0	25.2	1.20
BC1-25-15	11.0	41.2	36.6	38.9	18.4	28.7	1.59
BC1-37-4	12.1	49.1	55.1	52.1	20.4	27.9	1.37
BC1-67-24	10.7	48.7	18.3	33.5	18.3	27.1	1.48
BC1-86-21	10.4	39.5	28.9	34.2	20.6	27.7	1.35
BC1-88-6	11.0	52.8	64.2	58.5	22.2	29.4	1.33
BC2-1-74	11.0	44.2	31.6	37.9	18.0	23.8	1.32
BC2-17-21	12.1	44.4	34.4	39.4	21.5	30.5	1.42
BC2-20-17	12.6	42.4	40.2	41.3	20.0	23.7	1.18
BC2-6-16	12.1	48.9	42.2	45.5	20.5	28.2	1.37
BC3-14-12	12.0	43.8	38.8	41.3	21.8	12.9	0.59
BC3-31-10	10.4	44.5	31.1	37.8	19.9	30.5	1.53
BC4-13-46	12.2	47.0	27.7	37.3	19.0	25.7	1.35
BC4-13-7	10.3	47.0	29.1	38.0	19.7	27.3	1.39
BC4-31-46	9.3	45.8	24.9	35.3	21.0	28.8	1.37
BC4-41-8	9.9	47.4	26.3	36.8	19.8	29.0	1.46
BC4-41-87	9.9	46.3	36.7	41.5	21.0	26.5	1.27
BC4-42-59	9.7	48.5	36.7	42.6	20.1	26.3	1.31
BC4-46-59	10.8	46.9	37.8	42.3	19.9	23.9	1.20
BC4-93-2	10.1	44.2	28.8	36.5	20.6	28.3	1.37
BC4-BC4-11	11.8	47.4	52.6	50.0	21.1	26.0	1.23
Chemainus	11.8	44.5	44.1	44.3	21.6	23.7	1.10
Malahat	11.3	46.0	40.0	43.0	20.0	26.0	1.30
Meeker	11.9	48.9	39.4	44.2	18.6	21.3	1.15
Rudyberry	12.0	47.6	46.1	46.9	20.3	23.2	1.14
Saanich	10.9	42.6	39.3	40.9	20.5	26.0	1.27
Tulameen	11.9	43.3	26.1	34.7	20.4	28.2	1.38
Ukee	11.9	42.1	31.0	36.6	20.2	23.9	1.18
WSU 1499	12.1	55.2	39.7	47.5	15.7	15.5	0.99
LSD	1.2	5.8	13.4	8.6	1.6	4.5	0.23

[1]Data were subjected to analysis of variance with least significant difference (LSD) of 5% used to separate means.

Title: Red Raspberry Cultivar Development

Year Initiated: 2010 **Current Year:** 2010-2011 **Terminating Year:** 2014

Amount requested from the WRRC $8,000

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Project Description:
This program develops red raspberry cultivars, with an emphasis upon developing varieties exhibiting suitability for the processing and fresh market industries; suitability for machine harvesting, processing including IQF, dark fruit as replacement for Willamette, 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 and to replace the industry standard Meeker variety.

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 by 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 pathogens.

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 caused by *Phytophthora fragariae*, 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 already 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. However it is not adapted by the industry because it lacks root rot resistance that is needed when grown in infected soils, or heavy and poorly drained soils. More than 1.6 million plants of Chemainus have been already planted throughout the PNW. 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. Saanich also recently released from the PARC program and has been extensively planted throughout Washington State and the British Columbia with more than 1.2 million plants. 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. For a breeder there is no simpler test of value than what the farmer plant.

The PARC breeding program is using selections of *R. strigosus* as new sources of resistance to the root rot caused by *Phytophthora fragariae.* Hybrids and back-crosses are screened in greenhouse trials for resistant to different strains of *Phytophthora* they are than tested again in field conditions to insure that there are no escapes. The goal off cause is to combine root rot and RBDV resistant in single cultivar.

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 are also sent for evaluations to regions were the winter is much more extreme and are evaluated for winter hardiness. 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. Cultivars released from the program have the black raspberry, *Rubus occidentalis, R. crataegifolius and R. phoenicolasius* in their derivation. Nanoose, Ukee, BC90-8-11 and BC90-8-20 have the Dalhousie Lake selection of *R. strigosus* Maxim. in their derivations while the breeding parent BC90-19-34 which is highly resistant to rot root is a hybrid between Tulameen and the 'Lake George' selection of *R. strigosus.*

Objectives:

- Develop red raspberry selections, stressing suitability for machine harvesting, resistance to root rot and RBDV, high fruit quality that is dark in color, winter-hardiness, resistance to divergent aphid biotypes.
-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:
- Crossing blocks BC10 – use parents that are resistant to root rot, RBDV, MH well, and superior fruit quality.
- Evaluate the seedling populations planted in 2007.
- 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 BC92-15-9, 96-22R-55, BC3-14-12 and other potential cultivars to the propagators.
- Supervise distribution of advanced selections to North American propagators and growers and subsequently monitor their performance.
- Release Ukee and Rudyberry to propagators for plant sale and large growers' trials.
- Conduct collaborative research with researchers at USDA-ARS, Corvallis, WSU and AAFC.

Anticipated Benefits and Information Transfer:
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: (2010/2011)
Amount requested from the $US 8,000

Washington Red Raspberry Commission (WRRC)	**$CD 8,000**
Raspberry Industry Development Council (RIDC)	$CD 15,000
Lower Mainland Horticultural Improvement Association (LMHIA)	$CD 6,000
Growing Forward- Developing Innovative Agri-Products (DIAP)[1]	**$CD 96,000**

***Resource commitments* by**	**DIAP**	**Industry**
Salary	66,000	27,256
Travel	5,000	
Operating	25,000	2,570
Admin cost (15%)		4,174
Total	**$96,000**	**$33,000**

Budget Summary

Contribution	
RIDC	19,000
WRRC	**8,000**
LMHIA	6,000
Total industry	**33,000**
AAFC-DIAP	96,000
Total for project	**129,000**
Total cash funds available to the program	**129,000**

[1] DIAP proposal will be submitted by the BC industry for approval for 4 years (2010-2013).

Project Number: 13C-3419-7297

Title: Postemergence Perennial Weed Buckwheat (Bindweed) Control in Red Raspberries

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

Reporting Period: 2010-11

Accomplishments: The trial was conducted near Lynden (Randy Honcoop, cooperator) and 2010 was the second season of testing the effects of several herbicides on wild buckwheat (locally called bindweed). Three other trials testing the effects of potential and currently registered primocane management products and the Canada thistle control herbicide clopyralid on red raspberry were also conducted (at WSU NWREC and near Burlington (Sakuma Brothers farms, cooperator). Data for the first all trials will be presented at the red raspberry commission meeting for project review and at winter grower meetings during 2010-11.

Materials and Methods:
In 2009, treatments were applied April 7, April 17, and May 27 for preemergence, for caneburning, and for postemergence timings. Weed control was evaluated June 17 and then plots were weeded by the cooperator. Berries were sampled July 10, and primocane counts were made in April, 2010. The same plots were used in 2010. This year's treatments were applied April 2, May 4, and June 3 preemergence, for caneburning, and for postemergence timings. Weed control was estimated June 3 and June 30. Berries were sampled July 14, after which the raspberry block was removed by the cooperator. The design was a randomized complete block with four replicates.

Results:
2009 trial. Due to variability in the amount of seedlings found in each plot, there was not a significant affect of herbicide treatment on wild buckwheat control (Table 1). Still, the raw numbers indicate that several of these herbicides likely showed activity on wild buckwheat. Labels of all products mention annual *Polygonum* spp. weeds, although only Karmex and Aim labels specifically mention wild buckwheat (Karmex for control, Aim for suppression). No herbicide caused a reduction in berry yield, so it appears all these products are safe in raspberry. A second year of testing is warranted, particularly using combination treatments of these products, provided a suitable field can be located.

2010 trial: There were no difference in floricane counts amongst the 2009 treatments, indicating that these herbicides did not cause lasting effects to primocanes in 2009 (Table 3). While wild buckwheat did not show significant effects by any herbicide on June 3, by June 30 wild buckwheat control was significantly better than in non-treated plots (Table 2). Primocane reductions at the same evaluation date ranged from slight with preemergence herbicides (1 to 18%), to high with a second cane burning with Aim or Goal (67 and 59%, respectively) or Matrix or Sandea (63 and 55%, respectively). This level of injury from Matrix and Sandea was not noted during 2009, or in studies conducted in previous years, although evaluations were made at similar timings after postemergence applications. Should either product be registered for use in raspberry (note that neither is

currently registered), care should be exercised if applied in midseason. Berry yield was reduced by Matrix compared to nontreated raspberries, although yield in this older planting was low (Table 3).

Based on this two-year trial, it appears that wild buckwheat is controlled after two annual applications of Surflan, Karmex, or simazine applied at cane burning time. June applications with Aim, Goal, Matrix, or Sandea caused injury to primocanes in 2010, while Matrix also significantly reduced berry yield.

Table 1. Wild buckwheat density and control and raspberry yield following application of several herbicides in red raspberry (2009).

Treatment[a]	Timing	Rate	Wild buckwheat[b]	Berry yield[c]
		product/a	no./25 ft row (% control)	lb/a
Surflan	Cane burn 1	4 qt	31 (70)	1498
Karmex	Cane burn 1	3 lb	10 (90)	1383
Simazine	Cane burn 1	3 qt	2 (98)	1608
Devrinol	Cane burn 1	8 lb	33 (68)	1685
Aim + mso	Cane burn 2	6.4 fl.oz + 1%	51 (50)	1388
Goal + mso	Cane burn 2	2 pt + 1%	9 (91)	1559
Matrix + nis	POST	4 oz + 0.25%	30 (71)	1743
Sandea + nis	POST	2 oz + 0.25%	8 (92)	1785
Non-treated	---	---	103 (0)	1706
$LSD_{0.05}$	---	---	NS	NS

Means followed by the same letter are not significantly different ($P < 0.05$).
[a]Herbicides were applied April 7 (Caneburn1), April 17 (Caneburn2), and May 27 (POST).
[b]Weed control estimated June 17.
[c]Berries sampled by hand July 10.

Table 2. Wild buckwheat density and control following application of several herbicides in red raspberry (2010).

Treatment[a]	Timing	Rate	Wild buckwheat[b]	
			June 3	June 30
		product/a	no./25 ft row (% control)	% control
Surflan	Cane burn 1	4 qt	30 (97)	94 a
Karmex	Cane burn 1	3 lb	48 (88)	82 a
Simazine	Cane burn 1	3 qt	37 (93)	77 ab
Devrinol	Cane burn 1	8 lb	150 (66)	53 bc
Aim + mso	Cane burn 2	6.4 fl.oz + 1%	49 (93)	78 ab
Goal + mso	Cane burn 2	2 pt + 1%	3 (99)	96 a
Matrix + nis	POST	4 oz + 0.25%	---	89 a
Sandea + nis	POST	2 oz + 0.25%	---	95 a
Non-treated	---	---	152 (69)	47 c
$LSD_{0.05}$	---	---	NS	27

Means followed by the same letter are not significantly different ($P < 0.05$).
[a]Herbicides were applied April 2 (Caneburn1), May 4 (Caneburn2), and June 3 (POST).
[b]Weed control estimated June 3 and June 30.

Table 3. Raspberry floricane counts and primocane reduction following application of several herbicides in red raspberry (2010).

Treatment[a]	Timing	Rate	Floricane count[b]	Primocane reduction/injury[b]	Berry yield[c]
		product/a	no./25 ft row	% control	lbs/a
Surflan	Cane burn 1	4 qt	91	15 bc	2990 a
Karmex	Cane burn 1	3 lb	92	1 c	2508 ab
Simazine	Cane burn 1	3 qt	93	11 bc	2366 ab
Devrinol	Cane burn 1	8 lb	96	18 bc	2094 bc
Aim + mso	Cane burn 2	6.4 fl.oz + 1%	85	67 a	2330 abc
Goal + mso	Cane burn 2	2 pt + 1%	85	59 a	2503 ab
Matrix + nis	POST	4 oz + 0.25%	67	63 a	1476 c
Sandea + nis	POST	2 oz + 0.25%	82	55 a	2189 abc
Non-treated	---	---	94	25 b	2459 ab
$LSD_{0.05}$	---	---	NS	21	900

Means followed by the same letter are not significantly different ($P < 0.05$).
[a]Herbicides were applied April 2 (Caneburn1), May 4 (Caneburn2), and June 3 (POST).
[b]Floricanes counted April 2, 2010; primocane injury estimated June 30.
[c]Berries sampled by hand July 14.

APPLICATION COVER SHEET

Application Date: November 8, 2010

Name of Applicant Organization: Washington State University-Mount Vernon
Northwestern Washington Research and Extension Center

Principal Investigator: Timothy W. Miller, Extension Weed Scientist,
(360) 848-6138, twmiller@wsu.edu

Title of Project: Postemergence Perennial Weed Control in Red Raspberries

Year Initiated: 2011-12 **Current Year:** 2011-12 **Terminating Year:** 2011-12

Funding:

Total amount requested**: $ 4,015**

Title: Postemergence Perennial Weed Control in Red Raspberries

Year Initiated: 2011-12 **Current Year:** 2011-12 **Terminating Year:** 2011-12

Brief Description of Project: Perennial weeds are problematic in red raspberry production. In order to better control these weeds, it would be beneficial to gain registrations for new herbicides that have better activity on perennial weeds. A thorough testing of new herbicides in combination with existing products is necessary to achieve both improved weed control while maintaining crop safety. Products of interest include Casoron (diclobenil), Stinger (clopyralid), Matrix (rimsulfuron), and Sandea (halosulfuron). Sequential applications of these products will be tested for efficacy on various weed species and for crop safety in this project.

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

Perennial weeds frequently become established the first couple of seasons on a new raspberry block, when raspberry plants are small and not as competitive. Often, these weeds are present in the field prior to transplanting baby raspberries. If not controlled when the infestation is relatively small, perennial weeds become increasingly difficult to kill, ballooning herbicide and labor costs and becoming a major factor in reducing the longevity of raspberry plantings.

Trials with Stinger in healthy raspberries over the last few years have been encouraging. Importantly, floricane injury and berry harvest have not been significantly impacted by these applications. Since postemergence 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. I have some crop data dating back to the early 2000's with these products, including data from 2010 that showed these products applied in early June caused substantial injury to primocanes. These products applied in April, in sequence 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.

Relationship to WRRC Research priority(s): #2 Priority: Weed management

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

Procedures:
Plots will be established in 2011 in perennial weed-infested raspberries near Mount Vernon or Lynden. Herbicide applications will be made for several combinations of these herbicides in early spring (Casoron, granular and liquid formulations) and early spring (Matrix and Sandea) and late spring (Stinger). A typical application sequence could be Casoron (4G) in March followed by Matrix in April and Stinger in late June. Most sequences/combinations of these four 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.

In separate plots, additional new herbicides will be tested as available.

Anticipated Benefits and Information Transfer:
If positive, data from this experiment will be used to support new herbicide registrations in raspberries for Matrix, Sandea, and Stinger, 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:

	2011	2012	2013
Salaries[1]/	$ 1,500	$ 0	$ 0
Time-Slip	$ 1,000	$ 0	$ 0
Operations (goods & services)	$ 500	$ 0	$ 0
Travel[2]	$ 250	$ 0	$ 0
Meetings	$ 0	$ 0	$ 0
Other	$ 0	$ 0	$ 0
Equipment	$ 0	$ 0	$ 0
Benefits[3]	$ 765	$ 0	$ 0
Total	**$ 4,015**	**$ 0**	**$ 0**

Budget Details

[1]Salary for A/P scientific assistant Carl Libbey (0.54 FTE funded by WSU, 0.46 FTE funded by weed science program.
[2]Travel is for plot establishment, maintenance, and harvest.
[3]Benefits (41% for A/P scientific assistant, $615; 15% for time-slip help, $150).

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
Miller	WA Blueberry Com. 13C 3419 5229	5,660	7/1/10 to 6/30/11	5	Weed control in blueberries
Miller	WA Bulb Com. 13C 3419 8228	1,327	7/1/10 to 6/30/11	5	Herbicide combinations for weed control in ornamental bulbs
Miller	WA Strawberry Com. 13C 3419 8228	9,000	7/1/10 to 6/30/11	10	Weed control in strawberries
Miller	WA Raspberry Com. 13C 3419 3297	3,986	7/1/10 to 6/30/11	5	POST Canada thistle & bindweed control in red raspberry
Miller	NARF 13K 3419 6228	4,000	7/1/10 to 6/30/11	5	
Miller	13K 3419 7228	6,852	7/1/10 to 6/30/11	5	Weed control in cucumbers
Cogger et al.	USDA IOP	644,232	7/1/08 to 6/30/12	5	Weed control in vegetable seed
Miller & Miles	WA State Com. on Pesticide Registration 10A-3093-4028	11,123	1/1/10 to 12/31/10	15	Designing production strategies for stewardship and profits on fresh market organic farms
Miller & Walters	Specialty Crop 13A-3419-3350	128,932	9/30/09-9/30/12	15	Organic weed control in wine grapes
					Effect of cane burning herbicides on new raspberry cultivars

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: 2010

Accomplishments: In 2010, 71 crosses were made for cultivar development and 12 were made for germplasm purposes which totaled 83 crosses. An additional 9 crosses were made for an RBDV study, but these crosses will not be planted in the field. Of the 71 crosses for cultivar development, all had at least on RBDV resistant parent and 38 crosses had both parents resistant. Additionally, 41 of the crosses had at least one root rot tolerant parent. There were 7 crosses that had both parents RBDV resistant and both parents root rot tolerant. Approximately 7,300 seedlings were planted at WSU Puyallup in 2010. These will be evaluated in 2012 and 2013.

The planting of 7,100 seedlings planted in 2007 was evaluated for the first time in 2009, resulting in 42 selections. This seedling planting was evaluated for a second time in 2010 and 13 additional selections were made for a total of 55 selections in this planting. The planting of 4,860 seedlings planted in 2008 was evaluated for the first time in 2010, resulting in 45 selections. The parents that were most represented among the selections were: **WSU 1181**, **WSU 1447**, **WSU 697**, **WSU 1499** and **WSU 1451**. **WSU 1447** was a parent of 18 of the 45 selections in the Puyallup 2008 seedling field. Some of the crosses made in 2007 used fall-fruiting raspberries as parents. Nine fall-fruiting raspberry selections were made in 2010.

A new machine harvesting trial was planted at Lynden, WA with **Meeker**, **Willamette** and **Rudyberry**, eight BC selections, one ORUS selection and 88 WSU selections, 64 of which were selected in 2009. A new root rot evaluation planting was established at WSU Puyallup with **Meeker**, **Cascade Bounty**, 21 ORUS selections and 11 WSU selections. A new replicated planting at Puyallup was established with **Meeker, Willamette** and **Cascade Bounty** and 11 WSU selections.

The replicated planting established in 2007 at Puyallup was harvested in 2009 and 2010 (Table 1 and 2). **Meeker** had the highest two-year-total yield, although **WSU 1480**, **WSU 1499** and **Willamette** had comparatively high totals. **WSU 1503** had the highest yield in 2009 and the lowest yield in 2010. **WSU 1447** had low yields both years. **WSU 1439** was harvested only in 2010 and had yield similar to **Meeke**r, but much larger, firmer fruit with a midpoint of harvest 12 days after **Meeke**r. The 2008 planting was harvested for the first time in 2010 (Table 3). **WSU 1660** had the highest yield, with the dark fruited **WSU 1715** and **WSU 1716** also having high yields. **WSU 991** is a yellow-fruited raspberry that had been evaluated in the early 1990s, but not tested further because virus-free plants were not available. Virus-free plants of **WSU 991**were evaluated in this planting and found to be productive with large, firm fruit.

Much of the fruit in the machine harvesting trials were crumbly the first few harvests. Fruit quality improved for many of the selections later in the season. In the 2007 machine harvesting trial, **WSU 1447** was notable for having much better quality fruit than the cultivars and the other selections, particularly early in the season. Other selections in the 2007 machine harvesting trial that showed promise were **WSU 1455** and **WSU 1738**. **WSU 1579**, **WSU 1581** and **WSU 1582** are selections from the same cross. All three selections produce firm fruit that machine harvests well and have potential for IQF. In the 2008 machine harvesting trial, **WSU 1581** had better flavor than **WSU 1578**. **WSU 1948** was also identified as having IQF potential.**WSU 1660** had good machine harvest yields with good flavor, but probably not IQF quality. It also had high yields in the planting at Puyallup (Table 3).

Fruit samples were collected from the machine harvests and will be analyzed for total anthocyanins, soluble solids, pH and titratable acidity. The laboratory work has not yet been completed for these samples.

Twenty-two raspberry clones were tested for RBDV resistance by grafting, including 16 selections with a known RBDV resistant clone as a parent. In these tests, **WSU 1439**, **WSU 1530**, **WSU 1626**, WSU 1955 and **WSU 1960** tested resistant. From these results, it can also be inferred that **WSU 1067** and **WSU 1322** are also resistant to RBDV.

Publications/Presentations:

February 2010. Strawberry and Raspberry Cultivar Development. Lower Mainland Horticulture Improvement Association Meeting, Abbotsford, BC

July 2010. Machine Harvesting Open House. Burlington, WA

September 2010. Raspberry Propagation and the Washington State University Breeding Program. International Plant Propagators Society Western Region Meeting. Bellingham, WA.

Table 1. 2009-2010 harvest of 2007 planted raspberries, Puyallup, WA

	Yield (t/a)						Fruit rot (%)				Fruit weight (g)				Fruit firmness (g)			
	2010		2009		Total		2010		2009		2010		2009		2010		2009	
Meeker	9.7	a	10.7	ab	20.4	a	5.5	c	3.1	d	3.85	de	3.52	de	138	d-f	177	ef
WSU 1480	9.3	a	9.4	ab	18.8	ab	5.5	c	2.9	d	3.89	de	3.50	de	185	b-d	238	b
WSU 1499	9.6	a	7.9	ab	17.5	a-c	5.4	c	3.2	d	2.28	g	2.26	g	80	f	135	g
Willamette	9.2	a	7.8	ab	17.0	a-c	5.5	c	2.4	d	3.56	d-f	3.21	ef	141	d-f	173	ef
C Bounty	8.6	ab	8.3	ab	16.8	a-c	8.9	bc	5.3	a-d	3.40	ef	3.22	ef	95	f	158	fg
ORUS 1142-1	6.4	a-d	8.5	ab	15.0	a-d	10.9	bc	7.3	a-c	4.13	d	3.85	b-d	170	c-e	204	c-e
WSU 0991	6.7	a-c	8.2	ab	14.9	a-d	20.7	a	7.5	ab	6.88	a	5.44	a	161	c-e	214	b-d
WSU 1558	6.5		7.4		13.9		5.8		2.6	x	3.79		3.57	x	123		170	x
WSU 1455	5.8	a-d	7.9	ab	13.7	a-d	5.7	c	4.4	b-d	4.19	d	4.12	bc	142	d-f	180	ef
WSU 1503	2.2	d	11.4	a	13.6	a-d	14.2	ab	4.4	b-d	2.85	gf	2.78	fg	122	ef	167	fg
WSU 1530	6.2	a-d	7.1	ab	13.3	a-d	6.6	bc	2.9	d	3.55	d-f	3.19	ef	122	ef	157	fg
WSU 1582	3.4	cd	8.5	ab	11.8	b-d	10.4	bc	9.1	a	5.05	c	4.36	b	260	a	291	a
WSU 1452	5.8	a-d	3.9	b	9.7	cd	6.7	bc	3.6	cd	3.80	de	4.01	b-d	169	c-e	200	de
WSU 1447	4.3	b-d	4.5	ab	8.8	d	9.5	bc	4.4	b-d	3.55	d-f	3.62	c-e	222	a-c	235	bc
WSU 1439	9.8	a					9.2	bc			6.12	b			238	ab		
WSU 1638	4.0	cd					12.4	bc			4.05	de			207	a-c		
	6.7		8.0		14.7		8.9		4.5		4.06		3.62		161		193	

Values represent means of three 10 foot plots.

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

Table 2. 2009-2010 harvest of 2007 planted raspberries, Puyallup, WA

	2010								2009							
	Dates for percentage cumulative yield						Length of harvest season (d)		Dates for percentage cumulative yield						Length of harvest season (d)	
	5%		50%		95%				5%		50%		95%			
Meeker	7/9	b	7/22	bc	8/6	b-d	28	bc	7/3	ab	7/14	bc	7/26	bc	23	c
WSU 1480	7/7	bc	7/27	ab	8/12	ab	36	a	7/1	b-d	7/17	b	8/4	a	35	a
WSU 1499	7/1	b-d	7/13	e	7/30	ef	29	a-c	6/25	d-f	7/7	ef	7/20	de	24	bc
Willamette	7/1	b-d	7/14	e	7/31	d-f	30	a-c	6/23	f	7/6	f	7/17	e	24	c
C Bounty	7/3	b-d	7/16	c-e	8/5	c-e	33	ab	7/2	bc	7/14	bc	7/26	bc	24	c
ORUS 1142-1	7/3	b-d	7/16	c-e	8/6	b-d	34	ab	6/27	b-f	7/11	c-e	7/22	c-e	25	bc
WSU 0991	6/30	cd	7/10	e	7/26	f	26	bc	6/28	b-f	7/8	d-f	7/20	de	22	c
WSU 1558	6/29		7/10		7/27		28		6/25	x	7/8	x	7/22	x	28	
WSU 1455	7/2	b-d	7/13	e	7/30	d-f	29	a-c	6/26	c-f	7/9	d-f	7/28	b	31	a
WSU 1503	6/26	d	7/9	e	7/18	g	23	c	6/25	ef	7/6	f	7/20	de	25	bc
WSU 1530	7/3	b-d	7/14	e	8/6	b-d	34	ab	6/30	b-e	7/8	d-f	7/22	b-e	22	c
WSU 1582	7/9	b	7/26	b	8/8	bc	30	a-c	7/7	a	7/21	a	8/7	a	30	ab
WSU 1452	7/9	b	7/22	b-d	8/5	c-e	27	bc	7/2	ab	7/12	cd	7/22	c-e	20	c
WSU 1447	7/3	b-d	7/14	de	8/1	d-f	29	a-c	6/30	b-e	7/10	c-f	7/23	b-d	23	c
WSU 1439	7/20	a	8/3	a	8/16	a	27	bc								
WSU 1638	7/4	b-d	7/14	c-e	7/30	d-f	27	bc								
	7/4		7/17		8/2		29		6/29		7/11		7/24		25	

Three replications of 10 foot plots.

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

Table 3. 2010 harvest of 2008 planted raspberries, Puyallup, WA.

									2010									
	Yield (t/a)		fruit rot (%)		Fruit weight (g)		Fruit firmness (g)		Dates for percentage cumulative yield 5%		50%		95%		Length of harvest season (d)	
WSU 1660	11.1	a	3.8	c	2.82	d	117	ab	7/3	ab	7/14	c	8/1	a	29	ab
WSU 1715	9.6	ab	5.0	c	3.84	bc	107	bc	6/27	b-e	7/11	cd	7/29	ab	32	a
WSU 1716	8.0	a-c	6.0	c	2.87	d	101	bc	6/25	de	7/8	d	7/21	bc	27	ab
WSU 1581	6.0	b-d	5.9	c	4.01	b	136	ab	6/30	a-d	7/15	bc	8/4	a	35	a
Meeker	5.5	b-d	6.5	c	2.93	d	114	a-c	7/2	a-c	7/20	ab	8/5	a	33	a
WSU 0991	5.5	b-d	17.4	a	5.16	a	149	a	6/26	c-e	7/9	d	7/19	cd	23	ab
WSU 1578	3.7	cd	6.1	c	4.89	a	133	ab	7/2	a-c	7/15	bc	8/1	a	30	ab
WSU 1525	3.5	d	4.1	c	3.19	d	134	ab	7/5	a	7/21	a	8/5	a	31	ab
WSU 1553	3.3	d	12.1	b	3.36	cd	116	a-c	6/21	e	7/1	e	7/11	d	20	b
Willamette	3.0	d	5.8	c	2.97	d	113	a-c	6/22	e	7/6	de	7/19	cd	27	ab
C Bounty	2.7	d	6.7	c	3.20	d	80	c	6/26	de	7/9	d	7/27	a-c	32	ab
	5.6		7.2		3.6		118		6/28		7/12		7/27		29	

Three replications of 10 foot plots.

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

PROJECT: 13C-3755-5641

TITLE: Red Raspberry Breeding, Genetics and Clone Evaluation

CURRENT YEAR: 2011

TERMINATING YEAR: continuing

PERSONNEL: Patrick P. Moore, Scientist,
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' and 'Meeker' 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 83 crosses made in 2010 will be sown in 2010-2011. 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 2008 (5,000 seedlings) and the seedlings planted in 2009 (4,500 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 2008 and 2009 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 2009 will be harvested for the first time in 2011. The machine harvesting trial established in 2008 will be evaluated for the second time in 2011. Evaluations will be made multiple times through the harvest season.

4. 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.

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

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:	**2010-2011**	**2011-2012**
00 Salaries		
Ag Res Tech 2 (0.05) FTE	2,096	2,131
01 Timeslip Labor	33,000	33,000
03 Service and Supplies[1]	16,944	16,747
04 Travel	4,000	4,000
07 Benefits		
Timeslip	3,135	3,168
Ag Res Tech 2	825	954
Total	**$60,000**	**$60,000**

[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 2008 – Sakuma Bros	$3,000
Machine harvesting trial established in 2009 – Honcoop Farms	$3,000
Machine harvesting trial established in 2010 – Honcoop Farms	$3,000

Establishment and maintenance of new test planting

Machine harvesting trial to be established in 2011 – 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. and Hoashi-Erhardt	Northwest Center for Small Fruit Research	$83,022	2010-2011	Small Fruit Breeding in the Pacific Northwest
Moore, P.P. and Hoashi-Erhardt	Washington Red Raspberry Commission	$60,000	2010-2011	Red Raspberry Breeding, Genetics and Clone Evaluation
Moore, P.P. and Hoashi-Erhardt	Washington Red Raspberry Commission	$ 2,428	2010-2011	Machine Harvesting Evaluation of Raspberry Seedlings
Moore, P.P. and Hoashi-Erhardt	Washington Strawberry Commission	$28,000	2009-2010	Genetic Improvement of Strawberry
Moore, Hoashi-Erhardt, Cogger, Bary, Collins	Organic Farm Research Foundation	$38,640	11/08 to 12/11	Evaluation of Day-Neutral Strawberries in Organic Systems in Washington
Zasada, I.A. and Moore, P.P.	Northwest Center for Small Fruit Research	$13,500	2010-2012	Evaluation of *Rubus* spp. Hybrids for *Pratylenchus penentrans* Resistance

Pending Support

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	Title of Project
Moore, P.P. and Hoashi-Erhardt	Washington Red Raspberry Commission	$60,000	2011-2012	Red Raspberry Breeding, Genetics and Clone Evaluation
Moore, P.P. and Hoashi-Erhardt	Washington Red Raspberry Commission	$ 3,819	2011-2012	Machine Harvesting Evaluation of Raspberry Seedlings
Moore, P.P. and Hoashi-Erhardt	Washington Strawberry Commission	$37,000	2011-2012	Genetic Improvement of Strawberry

PROJECT: 13C-3755-3641

TITLE: Machine Harvesting Evaluation of Raspberry Seedlings

CURRENT YEAR: 2010

PERSONNEL: Patrick P. Moore, Scientist,
Wendy Hoashi-Erhardt, Scientific Assistant
WSU Puyallup Research and Extension Center, Puyallup, WA

Reporting Period: 2011

Accomplishments: 2,150 seedlings from 30 crosses were planted at Sakuma Bros. in 2008. Seedlings from the same crosses were planted at WSU Puyallup. The machine harvesting seedlings did not put on enough growth to justify machine harvesting in 2009. The planting was maintained in 2009 and most seedlings made sufficient growth to machine harvest in 2010. The selections were evaluated as they were machine harvested on five harvests in 2010 with 38 selections made. Most fruit from early harvests was crumbly, but some seedlings with good quality fruit were identified. The parents that were most represented among the selections were **Willamette**, **WSU 1447**, **WSU 1638** and **Chemainus**. **Willamette** was used in only one cross, but four selections were made within that cross. **WSU 1447** was used as a parent in seven crosses and was a parent of 26 selections. Seven of the 38 selections have a known RBDV resistant parent and 8 have a parent that may be resistant. Only four of the 38 have a root rot tolerant parent. All of the selections have been placed in tissue culture and should be planted in a machine harvesting trial, spring 2011.

PROJECT: 13C-2755-3641

TITLE: Machine Harvesting Evaluation of Raspberry Seedlings

CURRENT YEAR: 2011

TERMINATING YEAR: 2011

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 are 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. Approximately 10-20% of the selections in these machine harvesting trials harvested well enough to justify further evaluations.

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, and 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 was postponed to 2010. The budget was 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.

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

Year 4 - 2011
The same procedures that were followed in year 3 will be repeated in year 4 and then the planting removed.

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.

After discussions with Sakuma Bros the amount requested for 2011-12 is reduced from the original proposal ($11,064) to $3,819.

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	$4,056

Year 4 - 2011-2012

Plot maintenance, harvest and removal	$3,819

Collection, Coordination and Dissemination of area-wide Spotted Wing Drosophila Status/alerts in Berry Crops

November 15, 2010 - Final Report

Personnel: Peerbolt Crop Management
Tom Peerbolt, Principal Investigator
Julie Pond, Scout Supervisor, Research Associate

Reporting Period: 2010

General Objective:

Reduce grower crop losses and minimize/economize pesticide applications by collecting and disseminating timely, region wide, crop and field specific information on Spotted Wing Drosophila status to Northwest berry growers, public researchers, extension personnel and other stakeholders.

Specific Project Objectives:

1. Establish an online network in the Washington small fruit growing regions that would use standardized protocols and share weekly field scouting data on the status of SWD in a representative sampling of strawberry, blueberry and caneberry fields.
2. Make inputted field scouting data immediately available to researchers and cooperators through a password-protected area on a SWD module of our existing AgReports program
3. Post a publicly-accessed online regular, timely, SWD status reports based on aggregated field data.
4. Collect and send samples for researchers to verify vinegar fly species identification.

Results:

<u>Objective 1</u>. Establish an online network in the Washington small fruit growing regions that would use standardized protocols and share weekly field scouting data on the status of SWD in a representative sampling of strawberry, blueberry and caneberry fields. And <u>Objective 4.</u> Collect and send samples for researchers to verify vinegar fly species identification

In late March 2010, we hired two scouts to monitor Washington fields. They were assigned specific fields to monitor for Spotted Wing Drosophila (SWD) and given preliminary training. Training was an on-going aspect with this project. The trap design changed during the season and the identification of SWD adult flies was difficult at first. The insect is very small (2-3 mm) with red eyes. Adult SWD male flies have a black spot on the tip of each wing, immature males look more like the females, who have no black spots. However, the females have a serrated ovipositor. The scouts used several techniques to ID the fruit flies including a hand lens in the field and high-powered microscopes in the lab. We also sent questionable samples to researchers for verification.

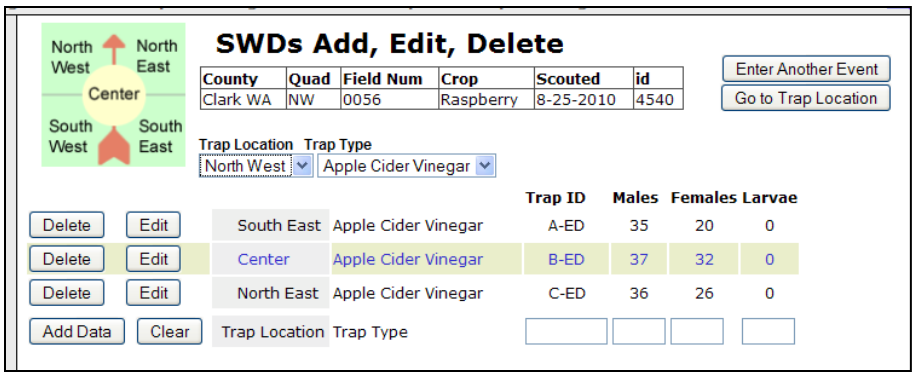
At the end of March and into early April we enrolled growers into the SWD scouting program, installed traps in their fields (one trap per five acres), and began scouting each field on a weekly basis.

We installed 195 traps in 80 fields belonging to growers in Lewis, Cowlitz, and Clark counties We scouted each field every week from April 1 to August 31.

Crop	No. fields
Strawberry	26
Raspberry	22
Blueberry	32

When this proposal was presented to the Washington Red Raspberry Commission, we had verbal agreements with cooperators in Northern Washington to participate in an area-wide SWD scouting program by following the same protocols and entering scouting data into a central database with charts accessible to the public. Unfortunately, we were not able to make this work during 2010. However, we are pursuing a new cooperative agreement for 2011.

By the time we had scouts in the field, the central dataset had been created with an Internet-access interface for inputting each week's trap results. (http://www.peerbolt.com/swd)



This picture is a screen shot of an actual field in Clark County. The field is only identified by its quadrant location in the county and a number code. All grower and field information were held in the strictest confidence. This particular field has three traps in it and the scout has noted the trap type (there were more than four trap types used over the season) and the location (the first one was on the edge of the southeast quadrant of the field). The numbers of SWD flies identified in that trap were also input.

Using the Internet user interface greatly reduced data entry time and made the scouts more efficient. The project PI, Tom Peerbolt, and Scout Supervisor, Julie Pond, were able to use the site's data and alert growers as soon as SWD presence suggested the need for control. The site also made it possible to archive each field's trapping history.

Vinegar Cider Trap 1

The trapping season started with the use of a lidded 32-ounce cup with five or six 3/16-inch holes drilled on one side, a design taken from preliminary lab trials over the winter. Two inches of apple cider vinegar was added to the cup and a 3x5-inch yellow sticky card was placed inside to catch any flies that did not drown in the solution. The trap was held to a garden stake by a transection of drainage pipe. Each week,

the sticky card and liquid were examined for flies, a new sticky card was inserted, and apple cider vinegar was replenished. Males were originally counted solely, but past research suggested that females were more likely to overwinter; so, we began to count both populations early in the season. When SWD presence was confirmed, pest count and any management recommendations were reported to individual growers.

Vinegar Cider Trap 2

In June, as a response to low trap counts in April and May, and the thought that flies could enter and exit the cup without touching the sticky card, the sticky card was removed and a small drop of unscented soap (Palmolive™) was mixed with the apple cider vinegar to break the surface tension of the solution. Upon contact with this solution, the flies were forced down into the solution instead of exiting the trap. The new trap design also made it easier to identify flies, as they stayed hydrated in the soap/apple cider vinegar solution. The traps continued to be checked weekly for male and female SWD. The solution was filtered through a screen- enclosed mason jar. Flies were collected from the filter screen and further identified by the scouts under magnification. Apple cider vinegar and soap were replenished each week.

Trap Placement

For all crops, traps were generally placed once every five acres and predominantly placed near the outside edges of each field near native habitat. If a field had SWD in 2009, traps were also placed near the center of that field where there would have been a higher chance for an overwintering population.

In raspberries, stakes were placed in the middle of planted row with the bottom of the cup a foot above the soil. Initially, traps were placed without concern for sun exposure. When it became obvious that traps exposed to the most sunlight had less trap catches than traps that were shaded for the majority of the day, all traps were moved to the northeastern side of plant canopies to ensure the least amount of sun exposure.

SWD Larvae Testing

Initially, SWD larvae testing was to take place one, two, and three weeks after a pesticide spray was reported in order to test the effectiveness of the spray. However, very early in the season we realized that we could not rely on trapping methods that were still a work in progress and chose to take larvae tests weekly, regardless of the SWD management practices in the field.

Sugar Water Solution Method 1

Initial testing involved a sugar water solution that had been found effective in preliminary lab trials over the winter. The solution for sugar water was 1 quart water to ¼ cup sugar. Between 50 and 75 raspberries, depending on the berry size, were added to an empty freezer bag. Ripening fruit was collected at random to get a fair representation of the fruit in the field. Fruit was crushed lightly in the bag, just enough to break the fruit surface. The sugar solution was poured over the fruit to a level that was at least double the fruit volume. If any SWD larvae were present, they would separate from the fruit

pulp and were then counted. The sugar content of the actual fruit determined if the fruit would float or sink when separating from the larvae (the higher the sugar content the more likely the fruit would float rather than sink).

Sugar Water Solution Method 2

In mid July, the sugar water solution method was altered slightly by leaving the fruit left in a sealed bag at room temperature for a few hours prior to adding the solution. This was to encourage the majority of larvae to exit the intact fruit and grip the inside of the bag.

Sugar Water Solution Method 3

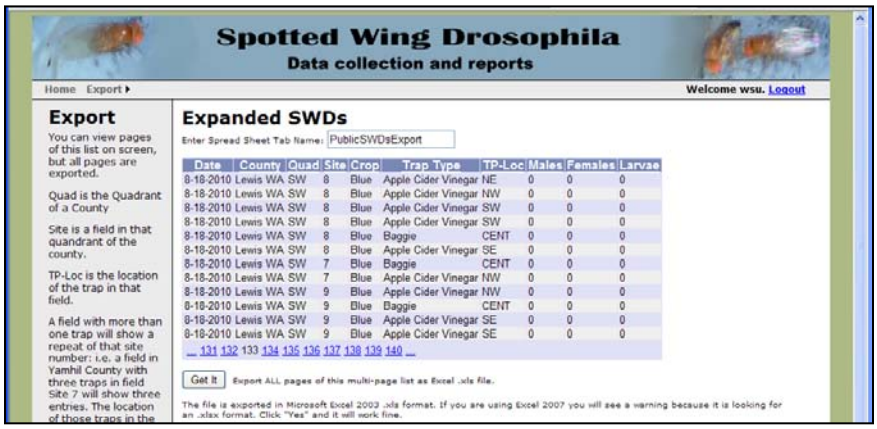
In August, the fruit bags were also placed in the freezer until they were semi-solid, which also encouraged any larvae to exit the intact fruit prior to adding the solution. Further research must be done to determine which modifications to the sugar water testing were most effective.

Salt Water Solution Method

Finally, at the advice of a processor, a salt solution replaced the sugar solution. That method included pouring a solution of 1 tablespoon salt with 1 cup water over about 2 lbs of fresh, intact berries in an open container. Within a few hours the salt solution caused more larvae to emerge from the fruit than the sugar solution and SWD were more easily counted as they separated further away from the fruit than in the sugar solution.

<u>Objective 2</u> Make inputted field scouting data immediately available to researchers and cooperators through a password-protected area on a SWD module of our existing AgReports program.

We established passwords for participating researchers and emailed the information to them.

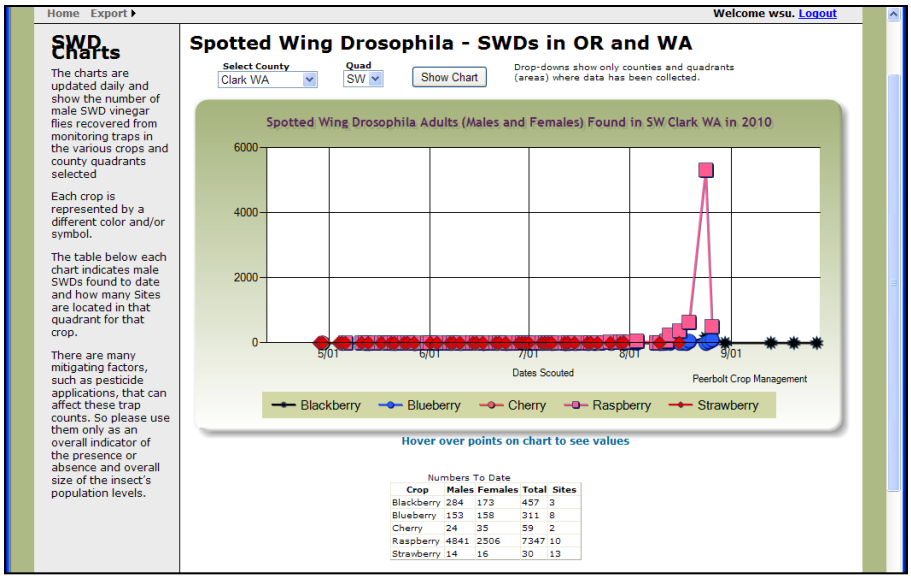


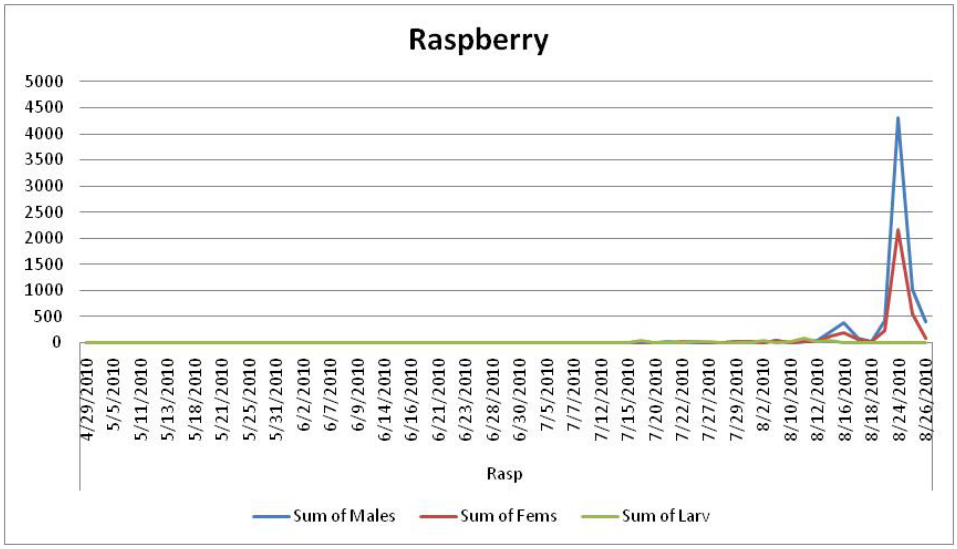
Researchers could log into the SWD site and download a spreadsheet containing all the information entered by the scouts. They could then use the data on their own computers to analyze the progression of the insect. In addition, the spreadsheet offered methods of sorting by crop, by county, by type of trap, and number of insects found. Several researchers told us that the information was quite useful.

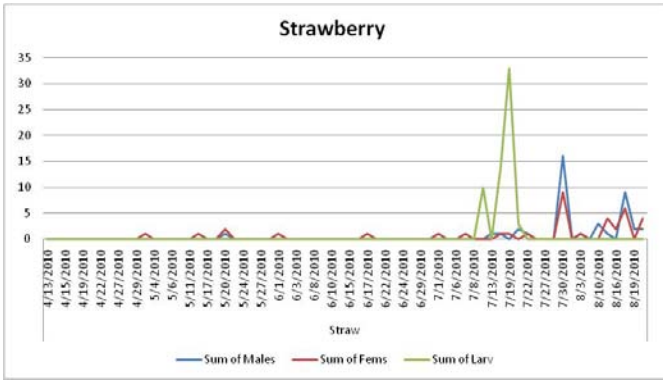
We also created charts that were accessible to the public. The charts showed all the crops we were scouting including stone fruits. We found that stone fruits, such as cherries, were major hosts for SWD, and berry fields in close proximity were often in danger of infestation.

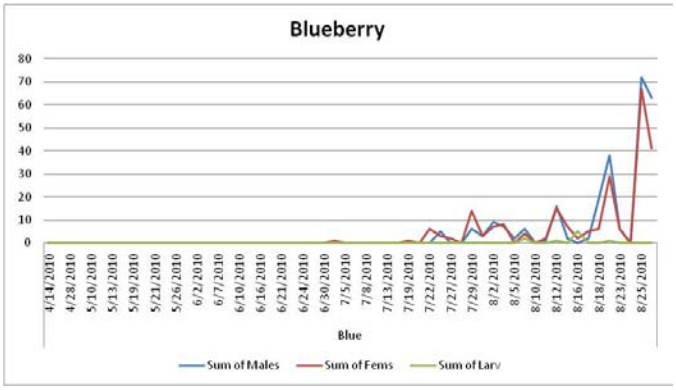
In the beginning, we had number values on the chart, but found that the chart looked chaotic. At this time, a viewer can point his/her cursor to a point on the chart and a date and the number of SWD found in the trap will appear.

The charts below show the progression of SWD by crop in Washington fields scouted by Peerbolt Crop Management (Lewis, Clark, and Cowlitz counties).









<u>Objective 3.</u> Post a publicly-accessed online regular, timely, SWD status reports based on aggregated field data.

We accomplished this objective in two ways:

1.The SWD website was updated weekly with any alerts and/or pertinent information.

2. We used the Small Fruit Update to expand on this information. SWD alerts were placed at the top of the Small Fruit Update and a link was embedded in the text to jump the reader to the more in-depth SWD information. The Small Fruit Update was sent out weekly to a list of approximately 750 berry growers, researchers, and industry personnel throughout the season.

Spotted Wing Drosophila
Data collection and reports

Home SWD County Charts — Researchers and Scouts please Login

FYI

Funding for the Spotted Wing Drosophila (SWD) scouting program that collects the data posted on this website comes from: the Oregon Department of Ag, the Washington the Red Raspberry, Washington Blueberry, and Washington Strawberry commissions, the USDA's Northwest Center for Small Fruits Research, and the clients of Peerbolt Crop Management.

Some field data in both states comes from Peerbolt Crop Management client fields. Data also comes from individual growers and researchers. All data is gathered and reported by identifying fields/sites by the quadrant of the county where they are located.

All grower contact

Spotted Wing Drosophila
SWD Data Collection and Reports for Oregon and Washington

This site has been created to collect scouting data and assist with disseminating that data to growers and researchers. The area being scouted includes Oregon and Washington westside counties. Information on this page is being made available as a service to the industry.

Spotted Wing Drosophila Update -- 8/31/10:

Scouting for SWD is ongoing in a number of counties in Washington and Oregon. WSU Extension has maps with locations and numbers in Whatcom County and Skagit County. OSU and Peerbolt Crop Management are scouting in Clark, Cowlitz, and Lewis counties in Washington, and in Oregon Multnomah, Washington,Yamhill, Clackamas, Polk, Marion, Linn, Lane, Douglas, Jackson, and Josephine counties. Charts and tables show the progression of SWD trapping in each of those counties. Use these maps and charts as an overall indicator only.

The picture shows SWD larvae in a blackberry. Picture taken by Julie Pond.

Alert: Spotted Wing Drosophila, all berries: The risk of fruit damage and economic losses to this new fruit pest continue to increase. For any berry crop still harvesting in the Northwest, it is highly recommended to take all appropriate measures to mitigate this risk.

General Comments:
New Comments
• Another week—another big jump in overall trap counts.
• The ongoing insecticide management program has been very effective where implemented consistently.
• This is the last week of reporting on the Oregon/SW Washington S- scout survey that was funded by the Oregon Department of Agriculture from April through August.
• Some vineyard and late season caneberry and blueberry SWD trapping will continue through the end of September in Oregon/SW Washington with 2 scouts funded through a Northwest Center for Small Fruits Research (USDA) grant.
• These weekly SWD report will continue.
• So far, while SWD adults have been recovered from some border areas of vineyards, very few adults have been

Small Fruit Update

News and opinions from Peerbolt Crop Management and BerriesNW sent out weekly during the growing season, and sporadically when we have something to share in the off season.

July 27, 2010

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Pest Alerts
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Crop Protection Materials Info
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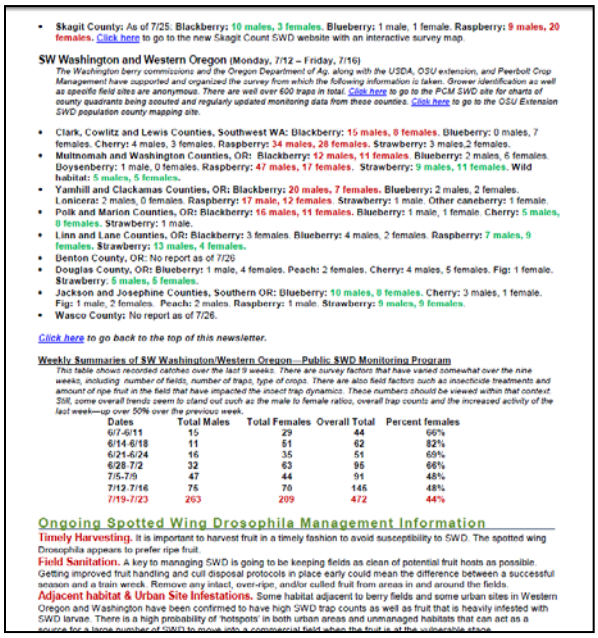
Videos of the week:
• Autonomous grape vine pruner: Click here.
• Autonomous robotic weeders: Click here.
• The Greenseeker, A precision fertilizer applicator: Click here.
Upcoming Meetings
The Weather Cafe by Rufus La Lone
Small Fruit Cold Storage Report

Alert
Spotted Wing Drosophila, all berries: This week has seen another increase in trap numbers.
This new pest poses unique difficulties for growers because we don't have any track record by which to accurately predict potential economic risk to our berry crops.
• While losses have been incurred in some u pick, fresh market, and home owner plantings, no conventional commercial growers have reported any economic crop damage attributed to SWD.
• Some organic growers have had good results using Entrust for SWD management and have not had any crop losses.
• Some other organically managed fields have reported damage.
• Growers are encouraged to pay very close attention to SWD through the rest of the season as the insect's population will continue to increase. In addition, Himalayan blackberries will ripen, providing a widespread regional host for SWD.

See the more extensive SWD weekly update below for in-depth SWD information.

Disseminating information for:
Washington
Washington Red Raspberry Commission
Washington Blueberry Commission
Washington Strawberry Commission
Oregon
Oregon Raspberry and Blackberry Commission
Oregon Blueberry Commission
Oregon Strawberry Commission
British Columbia
Fraser Valley Strawberry Growers Association
Raspberry Industry Development Council
B.C. Blueberry Council



• Skagit County: As of 7/25. Blackberry: 10 males, 3 females. Blueberry: 1 male, 1 female. Raspberry: 9 males, 20 females. Click here to go to the new Skagit Count SWD website with an interactive survey map.

SW Washington and Western Oregon (Monday, 7/12 – Friday, 7/16)
The Washington berry commissions and the Oregon Department of Ag, along with the USDA, OSU extension, and Peerbolt Crop Management have supported and organized the survey from which the following information is taken. Grower identification as well as specific field sites are anonymous. There are well over 600 traps in total. Click here to go to the PCM SWD site for charts of county quadrants being scouted and regularly updated monitoring data from these counties. Click here to go to the OSU Extension SWD population county mapping site.

• Clark, Cowlitz and Lewis Counties, Southwest WA: Blackberry: 15 males, 8 females. Blueberry: 0 males, 7 females. Cherry: 4 males, 3 females. Raspberry: 34 males, 28 females. Strawberry: 3 males,2 females.
• Multnomah and Washington Counties, OR: Blackberry: 12 males, 11 females. Blueberry: 2 males, 6 females. Boysenberry: 1 male, 0 females. Raspberry: 47 males, 17 females. Strawberry: 9 males, 11 females. Wild habitat: 5 males, 5 females.
• Yamhill and Clackamas Counties, OR: Blackberry: 20 males, 7 females. Blueberry: 2 males, 2 females. Lonicera: 2 males, 0 females. Raspberry: 17 male, 12 females. Strawberry: 1 male. Other caneberry: 1 female.
• Polk and Marion Counties, OR: Blackberry: 16 males, 11 females. Blueberry: 1 male, 1 female. Cherry: 5 males, 0 females. Strawberry: 1 male.
• Linn and Lane Counties, OR: Blackberry: 3 females. Blueberry: 4 males, 2 females. Raspberry: 7 males, 9 females. Strawberry: 13 males, 4 females.
• Benton County, OR: No report as of 7/26
• Douglas County, OR: Blueberry: 1 male, 4 females. Peach: 2 females. Cherry: 4 males, 5 females. Fig: 1 female. Strawberry: 5 males, 5 females.
• Jackson and Josephine Counties, Southern OR: Blueberry: 10 males, 8 females. Cherry: 3 males, 1 female. Fig: 1 male, 2 females. Peach: 2 males. Raspberry: 1 male. Strawberry: 9 males, 9 females.
• Wasco County: No report as of 7/26.

Click here to go back to the top of this newsletter.

Weekly Summaries of SW Washington/Western Oregon—Public SWD Monitoring Program
This table shows recorded catches over the last 9 weeks. There are survey factors that have varied somewhat over the nine weeks, including number of fields, number of traps, type of crops. There are also field factors such as insecticide treatments and amount of ripe fruit in the field that have impacted the insect trap dynamics. These numbers should be viewed within that context. Still, some overall trends seem to stand out such as the male to female ratios, overall trap counts and the increased activity of the last week—up over 50% over the previous week.

Dates	Total Males	Total Females	Overall Total	Percent females
6/7-6/11	15	29	44	66%
6/14-6/18	11	51	62	82%
6/21-6/24	16	35	51	69%
6/28-7/2	32	63	95	66%
7/5-7/9	47	44	91	48%
7/12-7/16	76	70	146	48%
7/19-7/23	263	209	472	44%

Ongoing Spotted Wing Drosophila Management Information
Timely Harvesting. It is important to harvest fruit in a timely fashion to avoid susceptibility to SWD. The spotted wing Drosophila appears to prefer ripe fruit.
Field Sanitation. A key to managing SWD is going to be keeping fields as clean of potential fruit hosts as possible. Getting improved fruit handling and cull disposal protocols in place early could mean the difference between a successful season and a train wreck. Remove any intact, over-ripe, and/or culled fruit from areas in and around the fields.
Adjacent habitat & Urban Site Infestations. Some habitat adjacent to berry fields and some urban sites in Western Oregon and Washington have been confirmed to have high SWD trap counts as well as fruit that is heavily infested with SWD larvae. There is a high probability of 'hotspots' in both urban areas and unmanaged habitats that can act as a

Conclusions:

Several SWD population factors were identified by the monitoring program that greatly aided growers in minimizing crop loss and insecticide application. However, it is important to remember that these factors come from a single season of data collection only. The 2010 growing season was one of the

coolest seasons in recorded history and this most likely impacted SWD numbers and overall population dynamics in the fields. Degree day accumulation, overwintering conditions, and many other seasonal factors will greatly influence SWD in ways that are as yet unknown.

Some preliminary findings from the 2010 season monitoring program:

- Traps showed that SWD populations were low in June-bearing strawberries and growers did not need to treat.
- Wild cherry trees were quickly identified as an early SWD host that could be a source of the insect's spread into nearby fields.
- There were some SWD 'hot spots' in the early season with moderately high trap counts, while most fields had very low numbers well into July. Further research will be needed to help explain these differences.
- For raspberries and mid-season blackberries, which began harvest in early to mid July, an insecticide application just before harvest (standard practice) plus an application in late July/early August was adequate for management in most cases. Very few losses due to SWD were reported in these crops.
- From July 20th to 25th, SWD reached population levels that threatened to cause major damage to ripening fruit, and regular spray programs were initiated by commercial growers to mitigate the threat.
- Raspberries and blueberries appeared to be preferred hosts with strawberries not as susceptible to SWD and not at as great a risk as the other berry crops during the 2010 season. However, this could be attributed to the cool spring, or it may be that SWD populations will normally remain low in the spring.
- Late season blueberries and caneberries faced a higher number of SWD, because the insect's short life cycle allowed the population to swell over the summer months. Scouting, therefore, should continue into September and possibly October in some regions.

APPLICATION COVER SHEET

Application date: November 08, 2010

Name of Applicant Organization/Company

Washington State University
Department of Biological Systems Engineering
L. J. Smith #204
Pullman, WA, 99164-6120

Principal Investigator

Shyam S. Sablani, Assistant Professor
Tel. 509-335-7745 (Off.), 509-432-4985 (Cell), Email: ssablani@wsu.edu

Co-PI and/or cooperator(s)

Karen Killinger, Assistant Professor
Tel: 509-335-2970, Email: Karen_killinger@wsu.edu

Title of project: Ultraviolet light (UV-C) treatment for control of storage rot and extension of postharvest life of red raspberries

Year Initiated (Current Year) 2010 Terminating Year 2012

Funding:

Total amount requested: $ 8,661 **(Year One)**

If you have applied for other funding for this project, list those sources here.

If you have received funding for this project, list those sources here.

Project No.: New

Title of project: Ultraviolet light (UV-C) treatment for control of storage rot and extension of postharvest life of red raspberries

Year Initiated 2010 Current Year 2010 Terminating Year 2012

Brief Description of Project Describing Objectives and Expected Outcome:

One of the most important limitations to increase raspberry production and marketing worldwide is Botrytis fruit rot/gray mold, caused by the fungus *Botrytis cinerea*. The morphological characteristics of the fruit also contribute to its susceptibility to fruit rot. The effective control of fruit rot is required for postharvest life extension of raspberries. We *propose* to use ultraviolet light
(UV-C, λ=254 nm) for reducing decay in red raspberries. The *long-term* goal of the proposed research is to improve quality and extend the postharvest life of red raspberries using ultraviolet treatment. The *specific objective* is to use of UV treatment to control gray mold decay of harvested raspberries, and to investigate its effects on physical and chemical quality after storage. Knowledge of fungal inactivation in raspberries as a result of UV treatment is essential for the UV system design to control fruit rot. Understanding the influence of UV treatment on the physicochemical changes in raspberries is integral for evaluating the efficacy of the UV applications for postharvest control of fruit rot. Each additional day without fungal growth is a significant improvement in shelf-life, translating to economic incentives for berry growers and traders, and improved quality for consumers.

Justification and Background:

Of all the small fruits, raspberries have the shortest shelf life. They become very soft in a matter of hours after harvest if not stored in cold temperatures, and mold grows easily on raspberries kept on consumer's counters at room temperature. The postharvest life of red raspberries is limited by fungal growth caused by *B. cinerea,* resulting in great economic losses. The lack of effective postharvest control of gray mold is the most important single factor limiting the sale of raspberry fruit for distant markets (Ellis et al., 2008). Although hot water treatments, biological control, and chemical applications have shown to reduce postharvest rots of fruits, each has limitations that can affect commercial applicability. Due to the delicate nature of raspberry fruit, hot water treatment is not a viable option to control fruit rot. Biological methods have not lived up to their early promise, and only a very limited number of biofungicides are available on the market. Moreover, the intensive use of chemicals has resulted in the buildup of chemically resistant fungi. Therefore, the emphasis in postharvest fruit protection has shifted from chemical to physical methods.

UV-C illumination as a postharvest treatment has proven beneficial to control decay in different fruits. The effects of ultraviolet light are explained in two ways. First, UV-C penetrates membrane cells and breaks down the deoxyribonucleic acid molecules through dimmer formation, rendering them incapable of reproduction, which results in germicidal effect damage. Second, UV-C induces resistance mechanisms in fruits against pathogens (Marquenie et al., 2002). This induced resistance to infection in plants is partially due to synthesis of pathogenesis-related proteins (Charles et al., 2009). Because of the wide variety of organisms present on food surfaces, dose levels required for disinfection vary

within food products. The ability of UV-C treatment to inactivate microorganisms also depends on their interaction with fruit surfaces. An investigation of the influence of UV-C treatment on fungal inactivation and its effects on physicochemical properties is integral to appropriate adoption of this method for postharvest life extension of raspberries.

During recent years, WSU researchers on this team have evaluated food processing methods including canning, freezing and drying for shelf-life extension of raspberries (Sablani et al., 2010a and b, Syamaladevi et al., 2009, 2010a and b). This helped us to identify optimal processing methods based on nutraceutical properties of raspberry fruit. We are currently evaluating UV-C illumination to control postharvest decay in tree fruits.

Relationship to WRRC Research Priority(s):

The proposed research is *relevant to the Washington Red Raspberry Commission's Postharvest and Product Development Priority 1* as it aims to control fruit rot and extend the postharvest life of raspberries.

Objectives:
The overall goal of this research is to extend the postharvest life of red raspberries by effective control of the fruit rot using UV-C treatment.
The specific objectives of this work are:

i. Evaluate the effects of UV-C treatment on postharvest fruit rot caused by *B. cinerea*
ii. Determine physical (e.g. color and firmness) and chemical properties (acidity, total soluble solids, anthocyanins, ellagic acid, phenolic contents and antioxidant activity) of UV-C treated red raspberries

Procedures:

Washington grown raspberries will be obtained from local farmers and processed within one day. Raspberries will be handpicked and harvested fully ripe. The fruit will be brought to WSU, Pullman via refrigerated transport. After selection, raspberries will be divided in three groups: (i) control sample (without any treatment), (ii) uninoculated sample subjected to UV-C treatment, and (iii) sample inoculated with fungi *Botrytis cinerea*.

For UV treatment, raspberries with natural micro-flora and inoculated with *Botrytis cinerea* will be exposed to different UV-C doses. Inoculation of the berries will be performed with suspensions of conidia of *B. Cinerea*. The inoculation will be done by immersion for 5s in conidiospore suspensions containing 5 x 10^5 conidia per ml. After inoculation, the fruit will be left to dry at room temperature. The recently acquired table-top UV-C system made by Reyco Systems, Inc. in Meridian, ID will be used. The system is capable of rotating the fruit during the treatment, thus providing a uniform dosage over the fruit surface. The UV-C illumination duration will be 1 to 3 minutes, and illumination dosages will be 0.5 to 10 kJ/m^2. Following UV-C treatment, the fruits will be stored at 4°C temperature. Non-illuminated raspberries will be considered as the control. Fungal growth and several quality attributes of untreated and treated samples will be determined.

Fungal evaluation The fungal evaluation will be performed daily for 10 days after treatment. Presence of mycelium will be used as the criterion for evaluation, regardless of the severity of infection.

Physical and chemical analysis Fruit skin color will be monitored with a colorimeter. Fruit firmness will be determined using a penetrometric method. TSS and TA will be determined for extracted juice using a refractometer and a titration method, respectively. Total anthocyanin will be extracted with 1% HCl:methanol, measured spectrophotometrically, and quantified using the appropriate molar extinction coefficient. Total phenolics will be determined according to the Folin-Ciocalteu procedure, and will be expressed as gallic acid equivalents (GAE) in milligrams per kilogram of fresh weight (Singleton et al., 1999). Ellagic acid will be determined by HPLC as described by Crozier et al. (1997). Analysis of total antioxidant activity will be conducted using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method. In this test, the scavenging of DPPH radicals will be monitored by observing the decrease in absorbance at 520nm which occurs due to reduction by antioxidants (Gordon, 2001).

Anticipated Timeline

1st year: Evaluate the effects of ultraviolet light on postharvest life of red raspberries.
2nd year: Determine the influence of UV-C treatment on physical and chemical properties of raspberries.

Anticipated Benefits and Information Transfer:

The proposed research will determine the effective dosage required to control postharvest decay in red raspberries. This scientific information will assist packers in the design of ultraviolet light-based postharvest treatments to extend the postharvest life of red raspberries, providing economic incentives to both raspberry growers and processing companies. In cooperation with the Washington Red Raspberry Commission, the findings of this research will be disseminated to selected raspberry processing companies and growers in the state of Washington, and presented at regional and national conferences.

References:

Charles, M. T., Tano, K., Asselin, A. and Arul, J. (2009). Physiological basis of UV-C induced resistance to Botrytis cinerea in tomato fruit. V. Constitutive defense enzymes and inducible pathogenesis-related proteins, *Postharvest Biology and Technology* 51: 414-424

Crozier, A., Lean, E. J. L., McDonald, M. S., Black, C. (1997). Quantitative analysis of the flavonoid content of commercial tomatoes, onions, lettuce, and celery. *Journal of Agricultural and Food Chemistry 45*, 590-595.

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

Gordon, M. H. (2001) In *Antioxidants in food: practical applications*. J. Pokorny, N. Yanishlieva, M. Gordon (eds.). CRC Press, Boca Raton, 2001: 71-84.

Marquenie, D., Michiels, C. W., Greeraerd, A. H., Schenk, A., Soontjens, C., Van Impe, J. F. and Nicolai, B. M. (2002). Using survival analysis to investigate the ffect of UV-C and heat treatment on storage rot of strawberry and sweet cherry, *International Journal of Food Microbiology* 73: 187-196

Sablani, S. S., Andrews, P. K., Davies, N. M., Walters, T., Saez, H., Syamaladevi, R. M., and Mohekar, P. R. 2010a. Effect of thermal treatments on phytochemicals in conventionally and organically grown berries, *Journal of the Science of Food and Agriculture* 90: 769-778

Sablani, S. S., Andrews, P. K., Davies, N. M., Walters, T., Saez, H., Bastarrachea, L. 2010b. Effect of air and freeze drying on phytochemical content of conventional and organic berries, *Drying Technology* (*In print*)

Syamaladevi, R. M., Sablani, S. S., Tang, J., Powers, J., and Swanson, B. G. 2009. State diagram and water adsorption isotherm of raspberry (*Rubus idaeus*), *Journal of Food Engineering* 91:460-467

Syamaladevi, R. M., Sablani, S. S., Tang, J., Powers, J. and Swanson, B. G. 2010a. Water sorption and glass transition temperatures in red raspberry (*Rubus idaeus*), *Thermochimica Acta* 503: 90-96

Syamaladevi, R. M., Sablani, S. S. and Swanson, B. G. 2010b. Aging of amorphous raspberry powder: enthalpy relaxation and fragility, *Journal of Food Engineering* 101: 32-40

Singleton V. L., Orthofer R., Lameula-Raventos R. M. (1999). Analysis of total phenols and other oxidation substrate and antioxidants by means of Folin-Ciocalteu reagent. *Methods in Enzymology* 299: 152-179.

Budget:

***Indirect or overhead costs are not allowed* -** No facilities and administrative fees (indirect or overhead cost) are allowed in WRRC funded contracts unless specifically authorized by the Board.

	2011	2012	2010
Salaries[1/]	$	$	$
Time-Slip	$5,028	$5,229	$
Operations (goods & services)	$1,650	$1,750	$
Travel[2/]	$1,500	$1,600	$
Meetings	$	$	$
Other	$	$	$
Equipment[3/]	$	$	$
Benefits[4/]	$483	$502	$
Total	**$8,661**	**$9,081**	**$**

Budget Details

[1/]Type of Personnel,

[2/]. To attend commission meetings, regional conference

[3/]

[4/] Benefits:

CURRENT & PENDING SUPPORT

Name: Shyam S. Sablani

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

- Record information for active and pending projects, including this proposal.
- All current efforts to which PD/PI(s) and other senior personnel have committed a portion of their time must be listed, whether or not salary for the person involved is included in the budgets of the various projects.
- Provide analogous information for all proposed work which is being considered by, or which will be submitted in the near future to, other possible sponsors, including other USDA programs.
- For concurrent projects, the percent of time committed must not exceed 100%.

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

NAME (List/PD #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Active:				
Sablani, Barbosa-Canovas, Tang	USDA-Special Research Grant "Food Security" through ARC/WSU	$160,059	July 01, 2008 to June 30, 2011	10%	Developing Innovative Packaging for Advanced Processing Technologies to Insure the Integrity and Safety of Processed Foods
Sablani, Andrews, Davies, Saez, Tang, Walters	BioAg Program/CSANR/ WSU	$59, 922	July 01, 2008 to December 31, 2010	10%	Nutritional Quality of Organic Fruits: Influence of processing on phenolic compounds, ascorbic acid, and antioxidant activity in organically grown fruits
Sablani, Jiang, Zhang	USA Dry Peas, Lentil and Chickpeas Council	$25,000	September 2010 - August 2011	10%	Developing Peas Based Biodegradable Food Service Items
Barbosa-Canovas, Bermudez-Aguirre, Sablani	CORANET	$767,481	January 2010-December 2012	10%	Improving thermal processing of foods sealed in military-ration polymeric trays
Tang, Rasco, Sablani, Davidson, D'Souza, Huang, Dunne, Gray, Lum, Perchonok	AFRI-Food Safety	$4,999,994 (my share: $500,000)	January 2011-December 2015	10%	Control of Food-borne Bacterial and Viral Pathogens Using Microwave Technology
	Pending:				
Sablani, Killinger	Washington Red Raspberry Commission	$17,742 Year one: $8,661	January 2011-December 2013	5%	Ultraviolet light (UV-C) treatment for control of storage rot and extension of postharvest life of red raspberries

Application Cover Sheet

Application date: November 30, 2010

Name of Applicant Organization/Company Address, City, State, Zipcode:
E.S. Cropconsult Ltd. 6145 171A Street. Surrey, BC, Canada, V3S 5S1

Principal Investigator
Carolyn Teasdale, Berry IPM Specialist, 1-604-841-0765, carolyn@escrop.com

Title of project:
Development of a monitoring and mass trapping program for Raspberry Crown Borer

Year Initiated (current year) 2010
Terminating Year 2011

Funding:
Total amount requested: $3000

Additional Funding Sources:
Raspberry Industry Development Council (BC) – funding to be requested
Oregon Raspberry and Blackberry Commission – funding to be requested
Lower Mainland Horticulture Improvement Association – funding to be requested
National Sciences and Engineering Research Council of Canada - funding confirmed

APPLICATION FORMAT

Title of project: Development of a monitoring and mass trapping program for Raspberry Crown Borer

Year Initiated 2010 **Current Year** 2010 **Terminating Year** 2011

Brief description of project:
This research will fine tune the use of pheromone-baited traps for monitoring and management of the raspberry crown borer. The raspberry crown borer, *Pennisetia marginata* (Harris), is a sporadic but serious pest of raspberries that has recently been found in raspberry fields throughout the Fraser Valley, including fields within a mile of the US border. The female-produced sex pheromone was identified in 2008 and has since been used to identify the optimal pheromone trap type for capture of male moths. We have two objectives for research in 2011. The first objective is to confirm a monitoring threshold that correlates crown borer moth trap catches with egg presence in Whatcom County and Fraser Valley raspberry fields. We expect to confirm a baseline trap catch value of 10 male moths per trap. The second objective is to evaluate lower densities of pheromone traps per acre for mass trapping. A minimum of two mass trapping densities will be tested. The efficacy of mass trapping will be evaluated through collection and dissection of wild females to see if they have been mated and through egg counts on the foliage. We expect mass trapping to reduce mating and egg counts by 65–95%.

Justification and Background:
The raspberry crown borer, *Pennisetia marginata* (Harris), is a sporadic but serious pest of raspberries. The raspberry crown borer is a challenging pest to monitor, as it has a two year life cycle, spending much of this time as larvae tunneled inside the lower canes (Lawrence 1904, Raine 1962). The adult moth flies between early August and September, but is difficult to spot in the field. Without a monitoring tool for this pest, growers depend on preventative drenches to protect their fields. The female-produced sex pheromone for the raspberry crown borer was identified in 2008 (Gries and Judd, unpublished data) and has since been evaluated as a monitoring tool in Fraser Valley raspberry fields. Raspberry crown borer moths were caught in all regions of the Fraser Valley where pheromone traps were set up, including fields less than a mile from the Washington border.

Field experiments in the Fraser Valley in 2009 and 2010 identified the best pheromone trap type, trap placement in the canopy, pheromone dose and lure longevity to maximize trap catches of male moths (Teasdale and Prasad 2009, Teasdale 2010). Preliminary monitoring data showed that where more than 10 moths were caught in a pheromone trap in the field during peak flight, raspberry crown borer eggs were consistently found in the field. This baseline trap catch value may be useful to growers to determine whether an insecticide treatment for raspberry crown borer is necessary. Another year of monitoring data in raspberry fields is needed to confirm this action threshold.

In preliminary mass trapping field experiments, a trap density of ten traps per acre was able to shutdown the response of males to low dose pheromone or "false female" traps. Mass trapping reduced the number of male moths caught in false female traps by 95% compared to traps placed in control areas. Field experiments in 2011 will evaluate the efficacy of lower densities of pheromone traps for mass trapping.

Relationship to WRRC Research Priority:
Although this research does not directly address a research priority identified by the WRRC, in a broader sense it addresses the issue of management of soil pathogens. Feeding activity by raspberry crown borer larvae facilitates entry for soil pathogens into the crown and roots (Lawrence 1904). Therefore, management of the raspberry crown borer will improve the health and vigor of a raspberry planting by reducing the number of wound sites that allow entry of soil pathogens. Recent outbreaks of the raspberry crown borer in the Fraser Valley and the proximity of infested fields to Whatcom County raspberry fields make this research pertinent to Washington raspberry growers at this time.

Objectives:

- To confirm a baseline trap catch value in monitoring traps as an indication of raspberry crown borer egg presence in raspberry fields
- To evaluate different densities of pheromone traps for mass trapping of raspberry crown borer

Procedures:

Monitoring traps (green standard delta traps, Contech Inc) will be set up in five raspberry fields in Whatcom county and 20 raspberry fields in the Fraser Valley for the duration of peak flight (mid-August to mid-September 2011). Washington raspberry field sites will be identified in collaboration with Colleen Burrows from WSU Whatcom County Extension. The number of male moths captured in each trap will be recorded at the end of peak flight. Egg counts will be carried out in late September on 200 leaves around each trap. Trap captures of male moths will be correlated with egg counts to confirm the preliminary action threshold identified in 2010.

Mass trapping plots will be set up in five commercial raspberry fields in the Fraser Valley where more than 10% of primocanes were infested with eggs in 2010. In each field, two densities of pheromone traps will be evaluated and compared to an untreated control plot. Field plots will be at least one acre in size and separated by a buffer region. Assessment of mass trapping efficacy will be carried out in two of three ways. Monitoring traps in both mass trapping and control plots will be baited with live female moths (reared in the laboratory at Simon Fraser University) and these female moths will later be dissected to see if they have been mated. Feral females found in the mass trapping plots and control plots will be collected and dissected to see if they have been mated, and egg counts will be carried out on the foliage in late September. The effect of mass trapping density on female virginity and egg counts in the plots will be statistically analyzed with one-way ANOVAs.

Anticipated Benefits and Information Transfer:

The raspberry crown borer is a difficult pest to detect in raspberry fields until populations are well established. The results of this research will provide Washington raspberry growers and extension agents with a protocol for pheromone-based monitoring of the raspberry crown borer. The synthetic pheromone is expected to become commercially-available in 2012 and can be easily incorporated into an integrated pest management monitoring program. As a management tool, the evaluation of pheromone-based mass trapping densities will help to develop a non-chemical option to control this pest. A full research report will be submitted to all funding partners in November 2011.

References:

Lawrence, W.H. 1904. The Raspberry root borer or blackberry crown borer. Washington Agriculture Experimental Station. 63. cited in McKern, J.A., Johnson, D.T. and Lewis, B.A. 2007. Biology and Control of the Raspberry Crown Borer (Lepidoptera: Sesiidae). Journal of Economic Entomology. Vol 100(2): 295-404

Raine, J. 1962. Life History and Behaviour of the Raspberry Crown Borer *Bembecia marginata* (Harr,) (Lepidoptera: Aegeriidae). The Canadian Entomolgist. Vol. 94 (11): 1216-1222

Teasdale, C. and R. Prasad. 2009. Development of a pheromone-based monitoring system for Raspberry Crown Borer. Report prepared for the Raspberry Industry Development Council, the Lower Mainland Horticulture Improvement Association, and the Oregon Raspberry and Blackberry Commission. E.S. Cropconsult Ltd., Surrey, BC. 18pp.

Teasdale, C. 2010. Development of a pheromone-based monitoring and mass trapping program for the Raspberry Crown Borer. Report prepared for the Raspberry Industry Development Council, the

Lower Mainland Horticulture Improvement Association and the Oregon Raspberry and Blackberry Commission. E.S. Cropconsult Ltd., Surrey, BC. 20pp.

Budget:

	2010
Salaries[1]	$19,500
Time-Slip (40 hours X $14/hour)	$560
Travel[2]	$2,700
Meetings (ORBC, WRRC, LMHIA)	$800
Equipment[3]	$2,285
Benefits[4]	$1,170
Total Costs	**$27,015**

1 Primary Investigator, 0.39% FTE
2 Mileage: 180 km/day X 30 days @ $0.50/km
3 Pheromone traps -mass trapping: $265/acre X 5 plots, $132/acre X 5 plots, monitoring: $12/field X 25 fields
4 Benefits: 6% of PI salary

Funding Sources	
WRRC (requested)	$3000
ORBC (to be requested)	$2000
RIDC (to be requested)	$6000
LMHIA (to be requested)	$1000
NSERC (confirmed)	$15000
Total Funding Requested	**$27,000**

Project No.: 13C-3443-5370

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

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

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

Collaborators: **Thomas Walters**, Small Fruit Horticulture Program[1]
Colleen Burrows, Whatcom County Extension Educator[2]
Don McMoran, Skagit County Extension Educator[3]
[1]WSU-Mount Vernon NWREC
[2]WSU Whatcom County Extension
[3]WSU Skagit County Extension

Accomplishments: Our major research & extension efforts were to develop a standard lab bioassay that would provide accurate and repeatable adult mortality of SWD on red raspberry treated with field aged residues of insecticides compared with the untreated check. In the course of this season, we have successfully overcome rearing issues associated with photoperiod, maintained quality control through introduction of 'wild' adults for enhancement of colony vigor and designed laboratory bioassay methods addressing the need for a constant source of red raspberry juice (sugars) in our artificial test bioassay arenas. We developed strategies to deal with microbial issues that initially plagued our bioassays. Our experimental agenda for the 2010 red raspberry season included multiple grower and research center applied applications in red raspberry and blueberry resulting in a better understanding of adult SWD mortality to field-aged residues. Results of our lab-aged bioassays detailed rates of mortality to different MOA. Field and lab testing with systemic activity of neonicotinoids to SWD egg and larval kill, indicates the potential for a curative approach.

Results:

Clean-up application prior to machine harvest

Following a clean-up spray on a mature 'Meeker' field on 24 June 2010 by a Skagit County farm using Brigade at 0.1 lb(AI)/acre and fifty ripe berries were sampled after 1 and 3 days posttreatment. These fruits were isolated individually in 2 oz condiment containers and mortality measured 24 hours later. On 5 July 2010, a Whatcom County farm applied a tank mix of 0.1 lb(AI)/acre bifenthrin and 1.5 lb lb(AI)/acre Malathion 8EC in 135 gallons/acre, 350 psi and 3 mph with a 300 gallon hydraulic sprayer. Fifty ripe berries were sampled after 1, 3 and 8 DAT and isolated in ventilated condiment containers as above. Both grower applied fields indicated precision applications with our field-based bioassays measuring 70 and 100 percent mortality for the Skagit County site and 94, 98 and 70 percent mortality for the Whatcom County site. Failure to apply a second protective spray by another Skagit County grower for SWD adults during mid-harvest resulted in low levels of fruit contamination during their last picking. Several other growers in Washington reported similar situations. Because of the cool and wet spring and the concomitant red raspberry

fruit infestation, the commercial and fresh market industries diverted much of that fruit to puree and frozen loose packs.

Laboratory 5 sec fruit dip bioassay procedure

Months of lab conducted dip bioassays with multiple iterations of arena design and ventilation systems, have provided us with a reliable laboratory protocol method which provides a natural environment for the very active and vagile SWD adults during testing when confined to our 2 and 4 oz condiment containers. Based on fall, 2009 studies, we have focused our field efficacy trials on 11 different insecticides. These include the OP Malathion, three pyrethroids (Brigade, Asana, Mustang Max), three neonicotinoids (Provado, Actara, Assail), the spinosyn Delegate, the diamide Altacor and two experimental combinations of a neonicotinoid and pyrethroid (Endigo, Leverage). The pyrethroids, Malathion, Delegate and both experimental combination formulations consistently performed better than the other compounds as contact and ingestion toxicants. The adulticidal potency of the neonicotinoids, although slow, is justified due to their potential curative activity, targeting SWD eggs and larvae inside the red raspberry, which compliments or synergizes their combination with the other mode of action compounds.

Precision applications of insecticides in the field

Because of the anticipated risk from SWD, commercial growers were hesitant to collaborate on replicated large-scale field plots in 2010. As a result, field trials were performed at the WSU NWREC red raspberry plot. For these tests, mature 'Meeker' were treated with a CO^2 backpack sprayer equipped with a 4.5' boom, and 4 nozzles (8002vs) at 60 psi and 110 gpa. Twelve treatments as mentioned above, were randomly replicated four times to sections of row showing good fruit sets of ripening red raspberries. Treatments were applied on 20 and 28 July. Ripening fruit from each flagged sector was selected after 1 and 6 DAT and 1 and 8 DAT, respectively. Five berries from each plot were individually placed in 2 oz ventilated condiment arenas and infested with one SWD adult and evaluated after 24 hours. Results of field-aged residues on red raspberry fruit were extremely variable, especially for Brigade and Malathion and other treatments for the 28 July applications at 8 day posttreatment. Perhaps residue persistence was affected someway by the late maturity of these fruit. Adult mortality was excellent for Mustang Max and experimental Leverage and Endigo at 1 DAT. Brigade EC provided 13% at 1 DAT and no SWD mortality on 8-day residue when bioassayed with lab-reared colony.

Fall red raspberries were treated on 9 September with eight registered insecticides on the WSU NWREC with a CO^2 backpack sprayer as above. Treatments were replicated three times and five fruits were taken from each plot and infested with a single SWD adult from the WSU NWREC laboratory colony. Malathion (100%) and Mustang Max (73%) provided quick knockdown at 1 DAT while Delegate showed 67% and 80% at 7 DAT. The generally slow acting Altacor provided 60% mortality at 1 DAT and Brigade WSB performed very poorly with only 13% and 7% mortality after 1 and 6 DAT. The field aged contact activity of the neonicotinoids showed modest toxicity for these late season red raspberries.

Curative activity of neonicotinoids on SWD larvae

Maturing red raspberry fruit were taken from fall bearing varieties grown at the WSU NWREC on 26 August 2010. Fifteen berries per treatment were dipped for 5 seconds in aqueous solutions of Actara, Assail, Provado, experimental Scorpion and UTC. These fruits

were held for 15 days to measure number of fruit infested with larvae or even emerged adults. Compared with the UTC which yielded 78% infested fruit, the bioassay indicated curative control of SWD at 36%, 7%, 0 and 7% for Actara, Assail, Provado and Scorpion, respectively.

Fruit ripeness and susceptibility

'Tulameen' and 'Meeker' red raspberries were studied to determine stage of ripeness most attractive to SWD for oviposition. One hundred berries were randomly selected from each cultivar with 25 berries representing each of the four ripeness categories, 4-7. Each berry was individually placed in 2 oz plastic condiment containers and held for SWD emergence. In 'Meeker' 4% of stage 5 were infested and 12% of both ripeness stages 6 and 7 were infested, compared with 12% of stage 6 in 'Tulameen.' Riper berries were more attractive to SWD for oviposition. This is supported by last year's data on ripeness in late season red raspberries.

Grower outreach for monitoring and management

A SWD trapping program was implemented in Whatcom County with 80 traps placed in strawberry, raspberry, and blueberry fields. Traps were monitored twice weekly and results were posted on a website showing locations of traps and numbers of flies trapped (http://whatcom.wsu.edu/ipm/swd/scouting.html); the website had over 1,100 hits over the season. Emails were also sent to grower participants when SWD were found trapped in their field. This map showed when SWD populations started to increase and where in the region they were problematic. During the growing season, field days were held at Boxx Berry Farm to discuss crop stage specific information. At two of these events, information on SWD was presented. Funds from the Commission assisted the monitoring and education of growers and public about SWD trapping and monitoring in Skagit County. The traps were placed in small fields and homeowner's backyards throughout Skagit County containing strawberries, blackberries, raspberries, blueberries and grapes. All 13 traps were monitored weekly with verification of positive SWD confirmed by researchers at WSU NWREC. Once confirmed positive sample results were uploaded to the WSU Whatcom County and WSU Skagit County webpage and email notifications were sent to area commercial growers in Skagit County. Through these outreach programs and websites, growers realized our system provided them with an area wide, early SWD detection system and overview of the seasonal population dynamics of this new economic pest.

Spotted wing drosophila workshops

Five regional workshops were presented in Lynden, Mount Vernon, Puyallup, Vancouver and Port Townsend. Each workshop lasted 4 hours and provided WSDA pesticide credits. These educational events informed growers about SWD monitoring and management and recruited growers/participants in a scouting program. Each workshop attracted 50-75 growers and attendees indicated that they increased their knowledge of SWD biology, monitoring, and management. Our workshops covered SWD identification, life cycle, monitoring tools including adult apple cider vinegar traps and fruit inspection, provisional insecticide recommendations based on fall bioassay tests supported by the Commission and discussion of organic and home garden management techniques. Overall, growers responded positively to our outreach programs and websites providing them with an area wide, early SWD detection system and overview of the seasonal population dynamics of this new economic pest.

Project No.: 13C-3443-5370

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

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

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

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

Funding: $13,077

Justification and Background: Spotted wing drosophila, *Drosophila suzukii* (Matsumura), SWD, is a direct pest of red raspberry, promoting premature softening and bacterial contamination, which results in rapid decay. Chemical controls for SWD in northwestern Washington red raspberry remain unclear since the recent invasion of the pest in late season 2009. A list of effective chemicals have been recommended but questions still remain about understanding the concept of preventative contact control of adults and the systemic curative activity of neonicotinoids on eggs and larvae inside the red raspberry. Grower experiences with tank mixes between these two different lethal actions have been positive along with the formulation of several promising experimental combinations comprised of a pyrethroid and neonicotinoid. These formulations will be evaluated with the potential for PNW and registrant support for an IR-4 project. More precise information on first SWD adult emergence, population dynamics and phenology between fruit ripeness and SWD fecundity and oviposition periods will provide raspberry growers with optimum timing for protective cover sprays. The $92 million dollar (2008 USDA NASS) red raspberry industry in Washington state could suffer severe economic losses in 2011 given a more normal season compared with 2010.

Objectives:

- Continue evaluating efficacy of labeled small fruit compounds, including experimental new mode of action insecticides.
- Field trial rotational and combinational partners for their efficacy and to minimize selection for SWD resistance (IRM).
- Research the phenology between SWD and red raspberry in western Washington.

Procedures: This project is now anticipated to be a 3-year project focusing on SWD population management, registration of new mode of action insecticides, monitoring and

seasonal phenology between the pest, and red raspberry. The procedures required to accomplish the objectives of this project are detailed below.

Lab bioassays. Bioassays will be performed, by dipping ripe 'Meeker' red raspberries from the Mount Vernon, WSU NWREC into aqueous field rates of labeled and experimental compounds for 5 seconds. Contact and residual persistence will be determined by placing 20 mature small fruits per treatment into individual 2 oz ventilated condiment containers and introducing 5 adult SWD at 1, 3, 5 and 7 days after treatment. These arenas will be held at 23^0C and examined after 24 hours to determine mortality levels. Translocation ability of select chemicals will be tested using a second group of 20 harvested red raspberries individually isolated in condiment containers with 1-2 adult egg laying SWD females for a 24-hour period. Females will then be removed and egg filaments will be circled and counted. Ten berries will be dipped into aqueous suspensions of insecticides reported to exhibit translaminar movement into plant tissue and the other 10 will serve as the untreated check. The treated berries will be held at room temperature and compared with the untreated berries for adult emergence to determine if the labeled field rates will translocate through the fruit's skin with enough lethal concentration to control egg hatch and/or maggot development.

***Field efficacy trials*.** Based on efficacy and residual persistence of several registered and experimental insecticides tested per bioassay protocol above, 5-6 will be chosen for individual field trials and within a cohort of 2-3 insecticide rotations if deemed necessary. Application timing for the first cover spray will be determined with seven standard apple cider vinegar traps placed at random in our 2.5 acre "Meeker' block at the NWREC. Additional population trends for SWD in NW Washington will be available to us from trapping programs implemented in Skagit and Whatcom counties after last year's commission support. Field scale applications will be applied with our Rear's hydraulic plot sprayer equipped to deliver 120 gpa at 1.8 mph with two 8004 nozzles on top of the boom, each vertical arms equipped with five D3-45 Tee Jet® nozzles. Treatments will be replicated 5 times on 30' by 10' plots. Berries from these treatments will be sampled at 1, 3 and 5 DAT and infested with adult SWD after the same method used for the lab bioassays. Individual pre and posttreatment fruit (n = 20/treatment) will be held in 3 oz. condiment containers at 23^0C to monitor for SWD larval emergence. Posttreatment mortality will be assessed at 5-7 days, pending rotational partners and harvest logistics.

Reproductive anatomy of female SWD. Females will be extracted at weekly intervals from vinegar traps at early emergence to late fall. Specimens will be dissected to investigate the reproductive cycle in relation to fruit development to better understand the period of fruit susceptibility.

Anticipated Benefits and Information Transfer: This study will provide a list of registered insecticides, including new MOA chemistries to manage SWD in red raspberry in Washington with emphasis on IRM and IR-4 residue projects. New knowledge about timing of chemical applications, phenology of red raspberry ripening characteristics, pest emergence, generations, population dynamics and overwintering ovary morphology will provide directions for identifying optimum window(s) to effectively

manage SWD. Monitoring in both Skagit and Whatcom counties will determine the first appearance of SWD for raspberry growers in these counties and extension education will provide this information to all interested growers through meetings and internet resources.

Budget:

	2011
Salaries[1/]	$5,000
Wages[2/]	$4,000
Employee Benefits[3/]	$2,577
Operations (goods and services)[4/]	$1,000
Travel	$500
Total	**$13,077**

Benefit details:

[1/]Research Associate Bev Gerdeman ($3,000), Agricultural Research Technician Hollis Spitler ($2,000).

[2/]One NWREC time-slip employee ($4,000).

[3/]Research Associate at 37.7% ($1,131), Agricultural Research Technician at 42.3% ($846), time slip employee 15.5% (600).

[4]/Field and lab trial supplies, field maintenance at WSU NWREC.

[5/]Vehicle maintenance and fuel for off-station travel to field sites.

CURRENT & PENDING SUPPORT

Name: Lynell K. Tanigoshi

NAME (List/PD #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
Tanigoshi, L.K., B. S. Gerdeman, G. Hollis Spitler	Washington State Blueberry Commission Active:	$11,301	2009-2011	5%	Season long chemical control of spotted wing drosophila, *Drosophila suzukii* (Matsumura) on Washington state blueberries
Tanigoshi, L.K., B. S. Gerdeman, G. Hollis Spitler	Washington State Red Raspberry Commission	$15,401	2009-2011	8%	Chemical control of spotted wing drosophila, *Drosophila suzukii* (Matsumura) in western Washington red raspberry, utilizing local monitoring while maximizing pollination, honey bee conservation and phenology between fruit ripening and infestation
Tanigoshi, L.K., B. S. Gerdeman, G. Hollis Spitler	Washington State Commission on Pesticide Registration	$15,401	2009-2010	8%	Chemical control of spotted wing drosophila, *Drosophila suzukii* (Matsumura) in western Washington red raspberry, utilizing local monitoring while maximizing pollination, honey bee conservation and phenology between fruit ripening and infestation
Tanigoshi, L.K., B. S. Gerdeman, G. Hollis Spitler	Washington State Red Raspberry Commission	$9,440	$2009-2010	5%	Effective chemicals for the control of *Drosophila suzukii* (Matsumura) in western Washington red raspberries, including new chemistries
Tanigoshi, L.K., B. S. Gerdeman, G. Hollis Spitler	Washington State Strawberry Commission	$9,000	2009-2012	5%	Efficacy of insecticides for control of spotted wing drosophila, *Drosophila suzukii* (Matsumura) in June bearing and day-neutral strawberry varieties
Tanigoshi, L.K., B. S. Gerdeman, G. Hollis Spitler	Northwest Agricultural Research Foundation	$6,000	2009-2010	3%	Organically acceptable approaches to managing spotted wing drosophila, *Drosophila suzukii* (Matsumura), in blueberry
	Pending:				
Tanigoshi, L.K., B. S. Gerdeman, G. Hollis Spitler	Washington State Strawberry Commission	$9,983	2010-2012		Efficacy of insecticides for control of spotted wing drosophila, *Drosophila suzukii* (Matsumura) in June bearing and day-neutral strawberry varieties
Tanigoshi, L.K., B. S. Gerdeman, G. Hollis Spitler	Northwest Agricultural Research Foundation	$6,000	2010-2011		New strategies for managing spotted wing drosophila, *Drosophila suzukii* (Matsumura) in organic blueberry
Tanigoshi, L. K.	Speciality Crop Research Initiative	$241,986	2011-2014		Biology and management of spotted wing drosophila on small and stone fruits

APPLICATION COVER SHEET

Project No: ARF 5703

Application date: November 8, 2010

Funds to: Washington State University, Pullman WA

Principal Investigator:
Inga Zasada
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Co-PI:
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Assistant Horticulturist
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Cooperator:
Jack Pinkerton
USDA-ARS (retired), currently employed WSU
Corvallis, OR

Title: Evaluation of Novel Nematicides for Root Lesion Nematode Control in Red Raspberry

Year Initiated___2009___ Current Year____2011____ Terminating Year___2011___

Total funding requested: $10,817
This project was funded by the WRRC for 2009 ($7,633) and 2010 ($9,840), and by the Washington State Commission on Pesticide Registration in the same amount for the same two years.

Title: Evaluation of Novel Nematicides for Root Lesion Nematode Control in Red Raspberry

Year Initiated___2009___ Current Year____2011____ Terminating Year___2011___

Brief Description of Project:
We want to plant several potential rotation crops following raspberries infested with *Pratylenchus penetrans* to see if we can substantially reduce *P. penetrans* numbers before re-planting with raspberry one year later. For some rotation crops (small grains), we think that *P. Penetrans* numbers will decline simply because the crop is not a host. For others (*Brassicas*) we think that incorporation of the crop residue will have a biofumigant effect. For potatoes, we think *P. penetrans* numbers will be reduced by Vydate applications to that crop.

Justification and Background:
The root lesion nematode, *Pratylenchus penetrans*, is prominent in western Washington soils (McElroy, 1992). *P. penetrans* feeding on roots reduces the capacity of the plant to uptake nutrients and water. The rate of raspberry decline depends upon the nematode population density and raspberry variety but usually occurs over a 3- to 4-year period. When this nematode is left unchecked and population densities increase in established raspberry plantings, significant yield loss can occur (Ellis et al., 1991). There are no effective nematicides labeled for post-plant treatment of the root lesion nematode in raspberry.

Previous studies evaluated the effect of Vydate, Nemathorin (fosthiazate), DiTerra, Cordon and mustard (*Brassica carinata)* seed meal on nematode population densities in a heavily infested field of 'Nootka' raspberries (Walters et al., 2009). Only Vydate and Nemathorin effectively reduced root lesion populations. The states of Washington and Oregon requested a Section 18 emergency label for Vydate on caneberries, but EPA rejected the request. The registrant (DuPont) is in discussion with EPA regarding the Vydate label, which may or may not clear the path for including raspberry on the Vydate label (Norm McKinley, personal communication). This, and coming changes to USEPA regulations regarding fumigant use on all commodities, means that pre- and post-plant management options available to control the root lesion nematode (*Pratylenchus penetrans*) in red raspberry are limited.

In the first two years of this project, we evaluated novel nematicides, including NemaQ, ProMax, Cordon, Multigard, BioForge, MCW2, BWE 1000, Lannate, Root Power and others in can, greenhouse and field trials. Unfortunately, none of these controlled *P. penetrans* or promoted raspberry growth in the presence of *P. penetrans.* We will continue to search for novel nematicides, and we will continue to work closely with the Vydate and fosthiazate registrants to promote inclusion of raspberry on the labels. However, we propose to shift our emphasis: for the final year of this study, we will evaluate the effect of crop rotation on *P. penetrans* populations. Although raspberry growers do not typically practice crop rotation before replanting, we believe that rotation will be an essential part of an integrated nematode control program in the future, as

nematode control options will continue to be limited. We will evaluate the effect of rotations with small grains, *Brassica* crops and potatoes following raspberry. This research directly addresses a #1 priority of the Washington Red Raspberry commission, soil fumigant techniques and alternatives.

Objectives:

1. Determine whether a one-year rotation with small grains, *Brassica* crops or potatoes can reduce *P. penetrans* population density between raspberry plantings.
2. Continue to screen novel nematicides against *P. penetrans* if they become available

Procedures:

In years 1 and 2, we evaluated available novel nematicides in controlled and field environments. In year 3 (2011) we propose to establish a replicated trial in microplots at WSU-NWREC containing raspberry plants infested with *P. penetrans*. We will kill and remove raspberry plants from most of these microplots, and will plant potential rotation crops (Table 1). Potatoes will be included because seed or production potatoes are both potential income-generating crops on which *P. penetrans* can be controlled with Vydate. 'Wheeler' rye and 'Saia' oats were previously identified as cover crops which do not exacerbate *P. penetrans* populations (Forge et al., 2000). *Brassica juncea* and *B. napus* are included because of their potential for biofumigation (Matthiessen and Kirkegaard, 2006). 'Sparkler' marigold demonstrated ability to reduce *P. penetrans* populations in a replanted apple orchard (Merwin and Stiles, 1989). One set of infested and of non-infested plots will be kept fallow, and a raspberry plants will be maintained in a final set of microplots. Each crop will be planted according to best practices for growth in our region. Once the brassica crops initiate flowering, they will be mown and incorporated. *P. penetrans* will be evaluated in soil samples taken from each microplot at rotation crop planting, and again at crop removal or incorporation: *P. penetrans* will also be evaluated in root samples from crops.

We will also conduct complementary greenhouse tests using *P. penetrans*-infested soil. One-gallon pots will be filled with *P. penetrans*-infested soil and the treatments in Table 1 established. Plants, or no plants for fallow, will be allowed to grow for 3 months at which time the experiment will be destructively sampled. Plant tops and roots will be weighed, and *P. penetrans* extracted from roots using intermittent mist (Ingham, 1998). A 50-g subsample of soil will also be collected from each pot and *P. penetrans* extracted with the Baermann funnel method. Novel nematicides (if any new ones become available) will be evaluated in the same experimental venue except that raspberry will be established in *P. penetrans*-infested soil and allowed to establish prior to the soil being treated with nematicide. All experiments will included non-infested controls, will be replicated at least 5 times, and conducted twice. Data will be transformed as required to meet ANOVA assumptions and will be analyzed using the SAS GLM protocol to determine treatment effects.

Table 1. Proposed treatments in crop rotation study at WSU-NWREC. All treatments in microplots infested with P. penetrans, except treatment 1, as noted.

1.	Non-infested check
2.	Continuous raspberry
3.	Potato
4.	'Wheeler' rye
5.	'Saia' oats
6.	*Brassica juncea* 'Pacific Gold'
7.	*Brassica napus*
8.	Fallow
9.	'Sparkler' marigold
10.	TBD (possibly another small grain selected for income potential)

Timeline:

Activity	**2011**
Microplot study	
Kill and remove raspberry plants	April
Plant rotational crops	April-June
Collect and evaluate soil and root samples	April, June, October, and December
Greenhouse study	
Collect infested soil	Feb
Plant cover crops	March
Collect and evaluate soil and root samples	March and July

Anticipated Benefits and Information Transfer:

This research will tell us the potential for rotational crops to reduce *P. penetrans* in one season between raspberry crops. Our research results will be presented to red raspberry growers at meetings (Berry Workshop, Lynden) and the annual WSU-NWREC field day. Results will also be communicated to the Washington Red Raspberry Commission and to Peerbolt Crop Management for inclusion in their newsletters.

References

Ellis, M.A., R.H. Converse, R.N. Williams, and B. Williamson, 1991. Compendium of Raspberry and Blackberry Diseases and Insects, p. 100. The American Phytopathological Society, St. Paul, MN.

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

Ingham, R.E., 1998. Nematodes, p. 459-490, Methods of Soil Analysis Part 2 - Microbiological and Biochemical Properties. Soil Science Society of America, Inc. .

Matthiessen, J.N. and J.A. Kirkegaard. 2006. Biofumigation and enhanced biodegradation: opportunity and challenge in soilborne pest and disease management. Critical Reviews in Plant Sciences 25.

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

Merwin, I.A. and W.C. Stiles. 1989. Root-lesion nematodes, potassium deficiency, and prior cover crops as factors in apple replant disease. Journal of the American Society of Horticultural Science 114:728-732.

Walters, T.W., J.N. Pinkerton , E. Riga, I. Zasada, M. Particka, Y. H., and C. Ishida. 2009. Spring Oxamyl Applications Suppress Plant Parasitic Nematodes in Established 'Nootka' and 'Willamette' Red Raspberry Fields. HortTechnology 19:762-768.

Budget[1/]:

	2011
Salaries	
Time-Slip[2/]	$ 8,000
Operations (goods & services)	
Travel[3/]	$ 1,115
Meetings	$ 202
Other[4/]	$ 300
Equipment	
Benefits[5/]	$ 1,200
Total	**$10,817**

[1/]Money will go directly to WSU because the majority of the work will be conducted by WSU employees.
[2/]Professional Worker (Jack Pinkerton, USDA-ARS retired) will be responsible for the day-to-day management of this research as a WSU employee.
[3/] Pinkerton 4, Zasada 2 trips, Corvallis - Mt. Vernon. Zasada will travel to Washington once a year to present research findings to the commission and at the WSU Small Fruits Workshop.
[4/] $300, Supplies for microplots
[5/] Benefits 15.0% for Pinkerton

***Other Funding:**
Total amount requested: $10,801
Other sources of funding:
Current funding already received for this project: $7,633 (WRRC) and $7,633 (WA Pesticide Commission)

*Budget data provided in "Other Funding" is for informational purposes only, for the Washington Red Raspberry Commission to understand the scope of the project. These estimated costs are not presented as formal cost-sharing and therefore do not constitute a cost-share obligations 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.

Current & Pending Support

Current and Pending Support – **Inga Zasada**

NAME (List/PD #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Active:				
Zasada & Pinkerton	Washington Blueberry Commission	4,000	1/200 10 -12/20 10	5%	Pathogenicity of plant-parasitic nematodes on blueberries
Zasada & Walters	Washington Red Raspberry Commission	9,840	1/2010 – 12/2010	2.5%	Evaluation of novel nematicides for root lesion nematode control in red raspberry
Walters & Zasada	Washington State Commission on Registration	9,840	1/2010-12/2010	2.5%	Evaluation of novel nematicides for root lesion nematode control in red raspberry
Walters & Zasada	Pacific Area-Wide Pest Management Program Integrated Methyl Bromide Alternatives	18,658	9/2010 – 8/2011	10%	Methyl bromide alternatives for raspberry nurseries
Tzanetakis et al.	USDA-NIFA-SCRI	1,463,234	9/2009 – 8/2013	10%	Management of virus complexes in Rubus
Zasada & Ingham	Oregon State University Agricultural Research Foundation	12,500	3/2010 – 2/2012	2.5%	Application of molecular techniques for the identification of root-lesion nematodes (*Pratylenchus* spp.) in Oregon
Zasada & Moore	Northwest Center for Small Fruits Research	13,500	10/2010 – 9/2012	5%	Evaluation of Rubus spp. hybrids for Pratylenchus penetrans Resistance
Walters & Zasada	Northwest Center for Small Fruits Research	73,735	7/2010– 6/20 13	10%	Biological and chemical alternatives to broadcast fumigation for raspberry
Weiland & Zasada	Northwest Center for Ornamental Research	9,300	7/2010-6/2013	2.5%	Etiology and Biology of *Pratylenchus penetrans* and *Verticillium dahliae* on Norway Maple
Walters & Zasada	Washington State USDA Specialty Crop Block Grant Program	130,257	10/20 10-9/2013	5%	Assessing the damage potential of the root lesion nematode *Pratylenchus penetrans* on raspberry varieties
Zasada, Walters & Burrows	USDA-NIFA-PAMP	164,474	9/2010-8/20 12	10%	Assessing the damage potential of the root lesion nematode *Pratylenchus penetrans* on raspberry varieties
Walters, Moore, Zasada, Grunwald, Peerbolt, Bolda	USDA-NIFA-RAMP	831,869	9/2010-8/2013	20%	A new way of managing soil borne diseases of raspberry in western states: development of decision making tools and sustainable management systems

CURRENT & PENDING SUPPORT

Name: TOM WALTERS

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

- Record information for active and pending projects, including this proposal.
- All current efforts to which PD/PI(s) and other senior personnel have committed a portion of their time must be listed, whether or not salary for the person involved is included in the budgets of the various projects.
- Provide analogous information for all proposed work which is being considered by, or which will be submitted in the near future to, other possible sponsors, including other USDA programs.
- For concurrent projects, the percent of time committed must not exceed 100%..

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

NAME (List/PD #1 first)	SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Current:				
Walters	Washington State Blueberry Commission	$7,000	1/1/2010 to 12/31/2010	5	Blueberry cultivar evaluation at WSU-NWREC, Mount Vernon
Walters	Northwest Agricultural Research Foundation	$9,813	1/1/2010 to 12/31/2010	10	Evaluation of small fruits at WSU-NWREC, Mount Vernon
Walters Zasada	Washington Red Raspberry Commission	$9,840	1/1/2010 to 12/31/2010	5	Evaluation of novel nematicides for root lesion nematode control in red raspberry.
Walters Zasada	Washington State Commission on Pesticide Registration	$9,840	1/1/2010 to 12/31/2010	5	As above (matching funds)
Walters Zasada	USDA-ARS Methyl Bromide Alternatives Program	$18,658	9/1/10 to 8/31/11	10	Methyl Bromide alternatives for red raspberry and forestry nurseries
Walters Zasada	Northwest Center for Small Fruit Research	$32,951	7/1/2010 to 6/30/2011	20	Biological and Chemical Alternatives to Broadcast Fumigation for Raspberry
Walters Zasada	WSDA Block Grant	$130,257	10/10-09/13	10	Assessing the damage potential of the root lesion nematode *Pratylenchus penetrans* on raspberry varieties
Zasada Walters	USDA-NIFA-Pest Management Alternatives	$199,223	09/10-08/12	10	IPM Tactics to Manage *Pratylenchus penetrans* in Red Raspberry: Providing Growers with Decision-Making Information
Walters Bolda Zasada Grunwald Moore Peerbolt	USDA-NIFA-RAMP	$828,811	09/10-08/14	25	A new way of managing soil borne disease of raspberry in western states: development of decision making tools and sustainable management systems