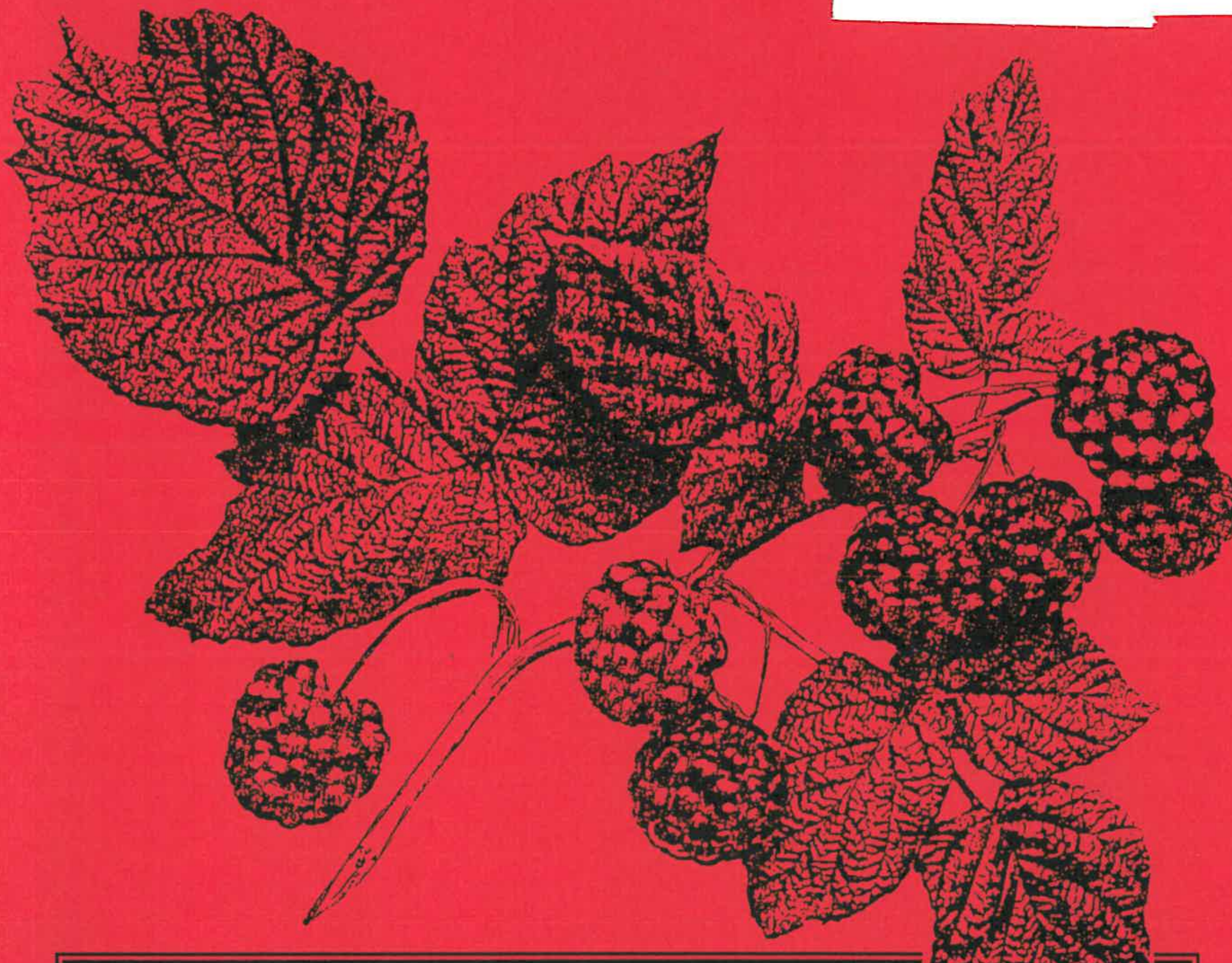

2006
Raspberry Research Proposals
&
2005 Progress Reports
to the
Washington State Raspberry Commission

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WSDA Representative

Bill Dallas WSDA P.O. Box 42560 Olympia, WA 98504 bdallas@agr.wa.gov 360-902-1925 FAX 902-2092

Key Personnel Contacts:

Henry Bierlink, Executive Director
1796 Front Street
Lynden, WA 98264
(360) 354-8767
FAX 354-0948
waredberry@verizon.net

Tom Peerbolt, Research Coordinator
Peerbolt Crop Management
5261 North Princeton St.
Portland, OR 97203
(503) 289-7287
FAX 289-7229
Tom@Peerbolt.com

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Commission	Meetings	Election of Officers
WA Red Raspberry	February, April, September, November, December	Fall

Summary
Budget Requests

LAST YEAR FUNDING REQUESTS (2005)

Ongoing Projects (2005)

Project No.	Short Title	Lead Scientist	Amount Requested
13C-3755-5641	Raspberry Breeding	Moore	$21,000
	Raspberry Cultivar Development	Kempler	$4,000
14C-4166-2815	Monitoring Fruitworm	Murray	$1,242
10A-3093-2403	Acquisition/Mechanical Harvester	Bristow	$3,000
13C-3419-3297	Weed Control in Red Raspberry	Miller	$7,060

New Projects (2005)

Short Title	Lead Scientist	Amount Requested
Insect/Mite Management	Tanigoshi	$17,319
Effect of Kaolin Clay Particle Mulch	Bristow	$3,700
Voluntary Grower Survey for Phytophthora fragariae	Murray	$40,000

CURRENT YEAR FUNDING REQUESTS (2006)

Ongoing Projects 2006)

Project No.	Short Title	Lead Scientist	Amount Requested
13C-3755-5641	Raspberry Breeding	Moore	……$16,000
131C-3543-4370	Integrating Insect & Mite	Tanigoshi	……$16,319
	Raspberry Cultivar Development	Kempler	… ..$ 4,800

New Projects 2006

Short Title	Lead Scientist	Amount Requested
Development of Value-Added Dried Raspberry	Clary	…….$19,392
New Stategies to Replace Nemacur	Riga	…….$10,325
Postemergence Canada Thistle	Miller	…….$ 2,330
Using An Alternate Year	Miller	…….$ 7,645
Effects of Drip Tape Placement	Walters	…….$ 5,575
Irrigation Deficits	Walters	,,,,,,,,,$ 7,581
Field Evaluation	Walters	…….$16,314

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ONGOING PROJECTS

PAGE

NEW PROJECTS

PROJECT: 13C-3755-5641
TITLE: Red Raspberry Breeding, Genetics and Clone Evaluation
YEAR INITIATED:2004
CURRENT YEAR:2006
TERMINATING YEAR: continuing
PERSONNEL: Patrick P. Moore, Scientist,
WSU Puyallup Research and Extension Center, Puyallup, WA

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

There has been a history of cooperation between the breeding programs in Oregon, British Columbia, and Washington. Crossing plans for each of the programs are exchanged and compared. Seed, seedlings and selections are exchanged among the programs. 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 96 crosses made in 2005 will be sown in 2005-2006. 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 2003 (5,500 seedlings) and 2004 (3,300 seedlings). Seedlings will be subjectively evaluated for yield, flavor, appearance, color, 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. Seedlings selected in 2005 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 2004 at WSU Puyallup will be harvested for yield, fruit weight, fruit rot and fruit firmness.

7. Plants will be multiplied in tissue culture and propagated for testing at other locations and grower trials.

8. 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 each of the selections in #5 above will be planted in a grower planting for machine harvesting evaluation. It is estimated that about 50-60 WSU selections will be planted in the field in 2005. Three plants of each selection will also be planted at WSU Puyallup for observation, use as a parent or future propagation.

2. The machine harvesting trials established in 2004 will be evaluated for the first time in 2006. Evaluations made in 2006 will be compared with those made in 2007.

3. Samples of fruit from selections that appear productive and dark fruited will be collected and analyzed for soluble sugars, pH, titratable acidity and anthocyanin content. Productive selections with high sugars and anthocyanin content may be desirable for puree/juice/bulk. A trial of promising selections for these uses may be planted with cooperating growers in 2006.

4. 10 selections were evaluated in machine harvesting trials in 2004 and appeared to harvest well and may be suitable for IQF. (**WSU 1253, WSU 1384, WSU 1387, WSU 1468, WSU 1469, WSU 1472, WSU 1499, WSU 1502, WSU 1507**, and **WSU 1539**) These advanced MH selections will be evaluated further.

A. These selections were propagated and planted in larger plots with cooperating growers. The purpose of these plantings is to produce enough fruit to evaluate IQF quality. If there is sufficient growth fruit will be evaluated in 2006.

B. These selections were planted in replicated plots at WSU Puyallup and harvest data will be collected in 2007 and 2008.

C. These selections were planted on a severe root rot site, and will be evaluated for their tolerance to root rot.

D. Selections that might be RBDV resistant will be grown in pots and will have RBDV infected plants placed next to them to determine if they become infected with RBDV.

5. Based on 2004 and 2005 observations of machine harvesting trials, **WSU 1452** and **WSU 1558** also appear to harvest well and may be suitable for IQF. **WSU 1206, WSU 1484, WSU 1480** and **WSU 1503** may have a place as a juice/puree berry. These selections will be included in evaluations in 2006 if plants are available, or may be evaluated in a larger planting for 2007.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:
This program will develop new raspberry cultivars that are more productive or more pest resistant. Modifications to the evaluation process will place increased emphasis on developing machine harvestable cultivars. Such cultivars may result from crosses made this year or may already be under evaluation.

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 supplies, greenhouse supplies and travel to research plots and to grower meetings to present results of research. This includes funds for tissue culture propagation of selections previously funded by the Northwest Center for Small Fruit Research. This proposal does not include grower expenses for machine harvesting trials.

Budget:	**2005-2006**	**2006-2007**
01 Timeslip Labor	12,500	9,000
03 Service and Supplies	5,100	5,010
04 Travel	1,400	1,000
07 Benefits		
Timeslip	2,000	990
Total	**$21,000**	**$16,000**

Current Support

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	Title of Project
Moore, P.P.	Northwest Center for Small Fruit Research	$90,000	2004-2006	Small Fruit Breeding in the Pacific Northwest
Moore, P.P.	Oregon Raspberry and Blackberry Commission	$1,500	2005-2006	Development of New Raspberry Cultivars for the Pacific Northwest

Project: 13C-3755-5641
Title: Red Raspberry Breeding, Genetics and Clone Evaluation
Personnel: Patrick P. Moore, Scientist, WSU Puyallup Research and Extension Center
Reporting Period: 2005
Accomplishments: Ninety-six crosses were made in 2005. In 91 of the crosses, selections identified in 2004 as appearing to be machine harvestable were used as one parent with a root rot tolerant parent, a RBDV resistant parent or another machine harvestable selection, the other five crosses were for germplasm purposes. Approximately, 10,000 seedlings were planted from the crosses made in 2004. 35 selections were made for cultivar development among the 5,500 seedlings that were planted in 2003. All 35 of the selections have possible root rot tolerance and 18 also have possible RBDV resistant parents. **Nootka, Prelude, Killarney, Cascade Bounty and WSU 1250** were the parents most represented among the new selections with over 2% of their seedlings selected. An additional 14 selections were made for germplasm purposes. A replicated planting of the selections identified in 2004 as potentially machine harvestable was planted at WSU Puyallup. Larger plantings of these selections were planted in southern and northern Washington and were also planted on a severe root rot to evaluate root rot tolerance. Those selections that have the possibility of RBDV resistance will be challenged with RBDV.

The 2001 replicated planting was harvested for the second time in 2005 (Table R1). This planting is in an area with a high level of root rot. Only 23 of the 66 raspberries in the 2001 planting were harvested in 2004 and only 12 were harvested in 2005. **WSU 1399** was the highest yielding in 2004 and had the highest two-year total yield, but the fruit is not of cultivar quality and will only be used for breeding. **WSU 1444** and **WSU 1342** had very good vigor on this site and good yields in both 2004 and 2005. **WSU 1342** may have RBDV resistance in addition to the root rot tolerance. These two selections will be propagated for planting in the machine trials.

A new machine harvesting trial was planted at Randy Honcoop's, WA. 90 raspberries were included in the new planting, with 46 WSU selections, 37 BC selections, one ORUS selection and 6 cultivars. The plantings established in 2002 and 2003 were machine harvested for the second time in 2005. With the wet weather during much of the harvest season, it was a challenge to be able to evaluate the selections. There was considerable fruit rot on all selections for most harvest dates. The cooperators were extremely accommodating in scheduling harvests. Observations were made on 5 harvests at each location. The most promising selections are **WSU 1253, WSU 1502, WSU 1452, WSU 1468** and **WSU 1469**. Several selections were identified for puree/juice uses. Fruit samples of 14 selections/cultivars were collected for evaluation as puree samples. Samples of promising selections were collected and are being analyzed for soluble solids, total anthocyanins, pH and titratable acidity.

Publications/Presentations:

Moore, Patrick P. 2005. 'Cascade Nectar' Red Raspberry. HortScience 40:256-257

January 2005. Strawberry and Raspberry fruit display. Northwest Food Processors, Portland, OR.

March 2005 Vancouver Small Fruit Workshop, Vancouver, WA.

June 2005. Raspberry Field Day, Puyallup, WA.

July 2005. Machine Harvesting Open House, Burlington, WA

July 2005. Small Fruit Open House, Mt. Vernon, WA

July 2005. Machine Harvesting Open House, Lynden, WA.

Table R1. 2004-2005 harvest of 2001 planted raspberries, Puyallup, WA

	Yield (t/a)			Fruit weight (g)		Fruit firmness (g)		Fruit rot (%)	Harvest Season			
	2005	2004	Total	2005	2004	2005	2004	2005	5% harvest	50% harvest	95% harvest	Length of harvest season
WSU 1399 *	**12.2**	**11.6**	**23.8**	**3.45**	**2.65**	**139**	**144**	**12.4**	**7/9**	**7/29**	**8/15**	**37**
WSU 1444	12.4 a	8.7 ab	21.0 a	4.51 ab	3.68 b	165 bc	162 cd	12.9 a	6/27 a-c	7/8 b-d	7/23 bc	26 a
WSU 1342	**10.8 a**	**7.8 a-c**	**18.5 a**	**5.02 a**	**4.80 a**	**199 a**	**224 a**	**12.6 a**	**6/22 cd**	**7/4 de**	**7/19 bc**	**27 a**
WSU 1459	7.6 b	9.9 a	17.4 ab	3.89 bc	3.46 bc	210 a	235 a	8.7 a	6/24 b-d	7/6 c-e	7/20 bc	25 a
C. Delight **	8.8	8.2	17.0	4.56	4.52	188	202	16.8	6/28	7/10	7/28	30
WSU 1462	**6.5 bc**	**10.1 a**	**16.7 ab**	**2.97 de**	**2.98 de**	**173 b**	**179 bc**	**15.8 a**	**7/2 a**	**7/13 a**	**7/28 a**	**26 a**
WSU 1451	6.8 bc	6.4 bc	13.2 bc	3.63 cd	3.08 cd	157 bc	141 de	12.5 a	6/30 ab	7/9 b-d	7/26 ab	26 a
WSU 1349	**4.8 bc**	**8.3 a-c**	**13.0 bc**	**2.47 e**	**2.59 e**	**126 d**	**119 ef**	**8.8 a**	**6/19 d**	**7/1 e**	**7/14 d**	**25 a**
WSU 1394	3.9 c	7.9 a-c	11.8 c	2.92 de	2.97 de	159 bc	143 de	14.5 a	6/28 a-c	7/10 a-c	7/23 bc	25 a
WSU 1244	4.3 c	6.6 bc	10.9 c	2.89 de	2.54 e	177 b	190 b	18.5 a	6/30 ab	7/12 ab	7/28 a	28 a
Meeker *	2.6	7.4	10.0	3.32	2.96	163	170	16.0	6/27	7/8	7/21	24
WSU 1376	**4.0 c**	**5.7 c**	**9.7 c**	**3.18 c-d**	**2.80 de**	**148 c**	**113 f**	**16.2 a**	**6/27 a-c**	**7/6 cd**	**7/19 bc**	**22 a**
Average	7.1	8.2	15.3	3.57	3.25	167	168	13.8	6/28	7/9	7/24	27

Clones marked with * or **, had only 1 or 2 plots harvested and were omitted from the statistical analysis.
Clones in **bold** have parents that may be RBDV resistant

Project No.: 13C-3543-4370

Title: Integrating Insect and Mite Management in Red Raspberry

Year Initiated: 2004 **Current Year:** 2005 **Terminating Year:** 2007

Personnel: **Lynell K. Tanigoshi**, Entomologist[1]
Jeanette R. Bergen, Agricultural Research Technologist II[1]
[1]Washington State University, Vancouver Research and Extension Unit

Justification: A review of insecticides and miticides in the *Pacific Northwest 2004 Insect Management Handbook* lists 11 synthetic pesticides recommended for effective insect and mite control in red raspberry. Seven of them are "older", broadspectrum, synthetic organic insecticides. Specifically the organophosphates (Malathion, Diazinon, Guthion), the carbamate Sevin and pyrethroids (Asana, Brigade/Capture, permethrin). The loss of these compounds would leave our red raspberry arsenal without the recently registered Brigade/Capture for economic control of root weevils and a few specific compounds that have been classified by the EPA as reduced-risk, OP replacements and biopesticides. EPA's FQPA guidelines and criteria for chemical registrations have created a strong reason to intensify our efforts to evaluate new chemistries, particularly the reduced risk and OP alternative insecticides for which EPA has expedited registration guidelines.

Objectives:

1. Continue validation of an interactive, area-wide orange tortrix program in southwestern Washington.

2. Detail occurrence, abundance, life history and failure to control re-emergence of economic populations of the rough strawberry root weevil, *Otiorhynchus rugosostriatus*, in northwestern Washington.

Procedures:

1. Beginning in March, 2005, we will again initiate on-farm grower meetings, subject to urgency, to develop details on implementation of the orange tortrix management project. Aspects of these meetings will discuss:
    a. In-field scouting for over-wintering larvae; sampling scheme for pheromone trap placement, evaluation and individual grower updates.
    b. Discussion and review about the life history of the orange tortrix and oblique banded leafrollers, their current treatment thresholds, timing of applications and choices of insecticides.
    c. Weekly meetings and email updates will review weather information, heat-unit accumulations, honey bee activity during prebloom, life stage activity of leafrollers as determined by field sampling/pheromone traps and interactive discussions with growers about these real-time parameters.
    d. Major emphasis will be placed on area-wide, coordinated field application of an agreed upon insecticide that will be applied, nearly simultaneous, over the red raspberry acreage within 1-2 days.

e. A calibration workshop and oversight activity will be coordinated to standardize proper calibration (e.g., gallonage, nozzle type, speed, and pressure) customized for the growth phase of red raspberry to be targeted.
f. Our research team will conduct treatment evaluation and sampling. These results will be discussed as soon as possible posttreatment with all of the area-wide growers.

2. Late winter weather permitting, naked-eye search amongst the decomposing floricanes will reveal presence/absence of over wintering adult rough strawberry root weevil. Soil samples, taken with a standard golf-cup cutter around emerging fruiting canes, will detect the presence of root weevil larvae and their life stage development. Larval samples will be reared to adults to determine species identification because there is potential for the presence of four species of *Otiorhynchus* in the same field. Early prebloom basal (i.e., April/May) treatments of bifenthrin and experimental insecticides will be applied with a tractor mounted plot sprayer equipped with an over-the-row boom. Only the lower 3 nozzles (D3-25 TeeJets) on each side of the row will be used to apply a basal application to drench the crown area thoroughly and surrounding soil and debris. Harvest and postharvest populations will be monitored as well.

Anticipated Benefits and Information Transfer:
Pending registrations of additional insecticides and miticides with different modes of action (e.g., neonicotinoids, carbazates, pyridine compounds), a root weevil, worm and spider mite control program that integrates biological control for spider mite control in red raspberry may be realized. In turn, this will lead to increased biological control and reduced pesticide usage in the crop. Results of this project are expected to advance grower understanding about how to attack 'weak-links' and susceptible life stages of the orange tortrix in commercial IPM red raspberry. Also, the growers will witness first-hand the dynamics associated with real or perceived resistance development of orange tortrix to bifenthrin across a physically isolated agricultural region known as the Woodlands Bottom. Our hope is to further show how important timing and placement of bifenthrin and spinosad are when targeting either adults or larvae of the orange tortrix with contact and stomach mode of action toxicants. Results from the area wide orange tortrix will demonstrate first hand how important timing and placement of insecticides are when targeting adults or larvae of the orange tortrix.

In cooperation with WSU Cooperative Extension personnel, research information will be disseminated at regional and national grower's meetings as well as through local, regional and national publications. Newsletters and WSU Vancouver REU's website will update industry on new developments as appropriate.

Budget:

		2005
01	Wages[1]	$13,125
03	Goods and services[2]	750
04	Travel[3]	1,000
07	Employee benefits (11% of 01)	1,444
Total		**$16,319**

[1]Time slip assistance for weevil and orange tortrix sampling and pheromone trap monitoring.
[2]Purchase of pheromone traps and lures for multiple grower fields, sprayer nozzles.
[3]Mileage at $0.40/mile per VREU motor pool.

Project No.: 13C-3543-4370

Title: Integrating Insect and Mite Management in Red Raspberry

Year Initiated: 2004 **Current Year:** 2005 **Terminating Year:** 2007

Personnel: **Lynell K. Tanigoshi**, Entomologist[1]
Jeanette R. Bergen, Agricultural Research Technologist II[1]
[1]Washington State University, Vancouver Research and Extension Unit
Todd A. Murray, Extension Coordinator, IPM Project
Washington State University Whatcom County

Reporting period: 2005

Accomplishments:

Safety rating of selected red raspberry insecticides/miticides, including the experimentals thiamethoxam and bifenazate were tested at full field rates in a laboratory Potter tower bioassay (Table 1). Bifenazate (Acramite) is an effective miticide and is very safe to beneficial predatory phytoseiid mites. Fenbutatin-oxide (Vendex) is the main miticide in red raspberry culture and this organotin compound continues to show excellent selectivity to all 3 *Neoseiulus. fallacis* populations tested in 2003 and 2004. The pending registration of Acramite will provide our industry with an excellent tandem of specific spider mite controls that are not highly injurious to beneficial mites and insects. Hexythiazox (Savey) responses in 2003 confirmed its selectivity and safety to beneficial mites. However, the 2004 bioassay scored Savey as being moderately harmful to adult phytoseiids. Savey will be revisited in 2005 along with several new arthropod pesticides. The experimental neonicotinoid thiamethoxam (Actara), was very safe to phytoseiid predators and we expect its full registration for red raspberry in the near future. It is an excellent foliar, systemic aphicide and shows excellent contact and stomach activity to adult root weevil. Compared with 2003, our 2004 field populations of *N. fallacis* were very tolerant to the recently registered spinosad (Success), Malathion and esfenvalerate (Asana). Surprisingly, the 3 populations responded variably from moderate to the expected very harmful when exposed to carbaryl (Sevin). Seven is extremely toxic to predatory mites and honey bees.

Figures 1 and 2 show average adult OT adults caught in pheromone traps from early April through postharvest in red raspberry in the Woodland bottoms and localities in Ridgefield and Vancouver, WA. Due to unseasonably wet and cool weather during May and June, our area wide consensus for adult moth clean-up sprays prior to harvest was somewhat erratic. However, the choice of insecticides (i.e., Success and Brigade) provided excellent preharvest adult suppression based on a threshold of 60-70 orange tortrix/week. This timing resulted in very low incidence of larval contaminants for machine harvest berries. Because of soft and moldy fruit this year, much of the traditional IQF fruit was sold as juice and puree quality. The growers for the second year have been pleased with the program's monitoring scheme and our interpretation of pheromone numbers as they related to second brood or larval hatch so critical to IQF marketed fruit. Compared with last year's populations trends and the marked weather differences between both years, the biology of the regionally adapted orange tortrix populations resulted in very similar population patterns when their biological clock was reset at time of overwintering adult emergence beginning in late March.

Table 1. Safety ratings of selected red raspberry pesticides to *N. fallacis*.

Pesticide	Common	Chemistry	Honcoop 2003	Honcoop 2004	Mayberry 2003	Mayberry 2004	Sakuma 2003	Sakuma 2004
Acramite	bifenazate	diphenyl	L	L	L	L	L	L
Actara	thiamethoxam	neonicotinod	M	L	L	L	L	L
Asana	esfenvalerate	pyrethroid		M		L		L
Brigade	bifenthrin	pyrethroid	H	L	M	M	L	M
Capture	bifenthrin	pyrethroid	H	M	M	M	M	L
Diazinon	diazinon	organic phosphate	H	M	M	M	L	M
Malathion	malathion	organic phosphate	H	L	H	L	M	L
Savey	hexythiazox	carboxamide	L	M	L	M	L	M
Sevin	carbaryl	carbamate	M	H	H	M	H	M
Success	spinosad	fermentation	M	M	L	L	M	L
Vendex	fenbutatin-oxide	organic-tin	M	L	L	L	L	L

L = Safe = >33% mortality.
M = Moderately harmful = 33-66% mortality.
H = Harmful = 66-100% mortality.

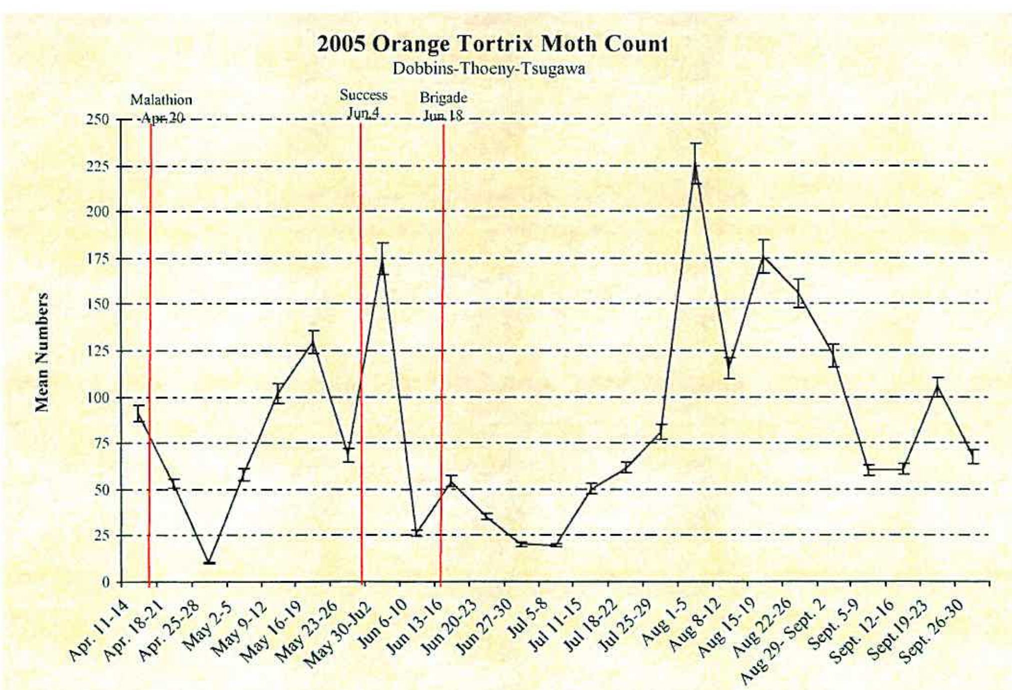


Fig. 1. Population trends, Woodland Bottoms, WA.

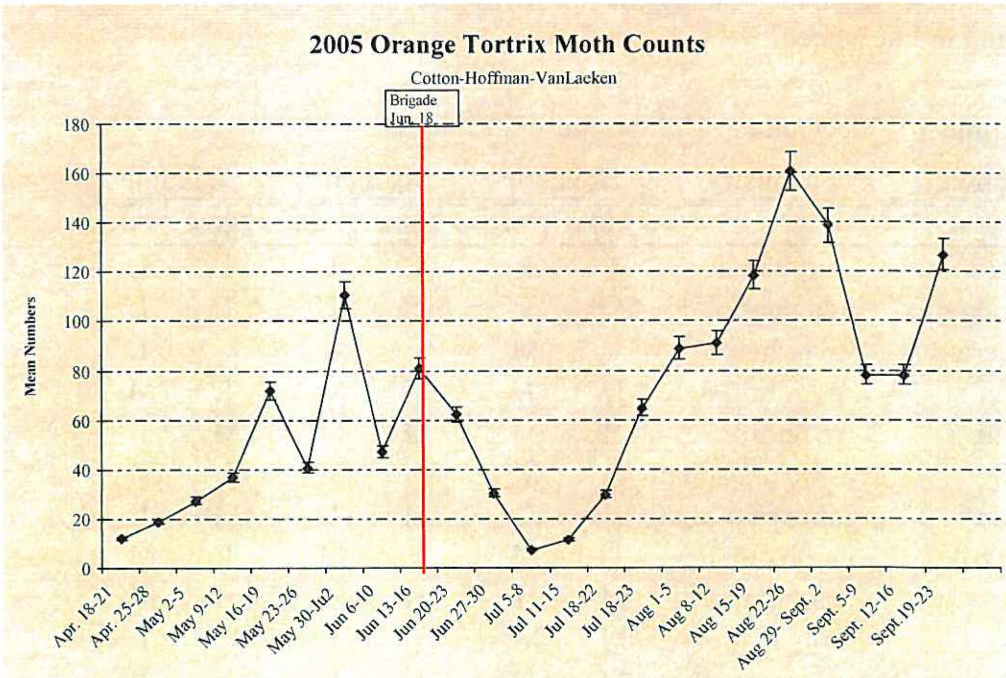


Fig. 2. Population trends, Ridgefield and Vancouver, WA.

Progress Report

Title: Red Raspberry Cultivar Development for the Pacific Northwest

Personnel: Chaim Kempler, Fruit Breeder, KemplerC@agr.gc.ca

Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre (PARC)
PO Box 1000, 6947 #7 Hwy. Agassiz, BC, Canada V0M 1A0
Tel: (604) 796-2221 ext. 224. Fax: (604) 796-0359
Website: http://res2.agr.ca/parc-crapac/agassiz/progs/crop_science/kempler_e.htm

Reporting period: 2005

Funding in 2004 was received from the BC Raspberry Industry Research Council, Washington Red Raspberry Commission, and Lower Mainland Horticultural Improvement Association (LMHIA), royalties collected on PARC cultivars and Agriculture and Agri-Food Canada's Matching Investment Initiative (MII).

Accomplishments:

The latest releases from the PARC program performed very well on large growers' trials. Cowichan established very well with excellent vigorous growth. It machine harvests well and produces high quality fruit that is also suited for the fresh market; however, it does show some susceptibility to root rot. Chemainus (tested as BC89-33-84) performed extremely well. It machine harvests very well, producing high quality fruit that is suited for both the fresh and for the IQF processing markets. The latest named cultivar, Sannich (tested as BC89-34-41), tested on farmers' trials, has gained acceptance by commercial producers. It produces very high yields of high quality fruit that is machine harvestable and exceptionally flavorful.

This year machine harvest (MH) trials that were planted in 2002 and 2003 were evaluated for the second time. A total of 7 selections were identified as promising; they are already being propagated for advanced, large-scale grower's trials. A new MH trial was planted on the Hancoop farm. It will be evaluated in 2007.

During the 2005 harvest season, the 2001and 2002 plantings were evaluated for yield, fruit traits and harvest season. Harvest data is presented in Tables 3-4. In 2005, thirty-six selections had tested RBDV positive for the first time, and most of them will be discarded. Approximately 2600 new seedlings were planted. They are from PARC crosses made in 2004, all with one or two parents that are resistant to root rot and RBDV.

Notes on cultivars and potential new cultivars:

Malahat (Meeker x BC/SCRI 7853/116):

Malahat is still the leading cultivar planted for the early fresh market. It ripens very early and has superior fruit quality. In the past few years, some farmers have planted Malahat on marginally suitable land which resulted in poor plant stands and dead plants. Plants of Malahat are very susceptible to root rot; therefore, it should be planted on well-drained soils that are free of root rot or on raised beds that provide a better-drained root zone. Malahat is suitable for machine harvesting producing a high quality IQF and processing crop. Malahat is very suited for switching between hand and machine harvesting depending on the season and labour availability. Because Malahat ripens earlier than Meeker, it has allowed the producer a longer harvest season and a better utilisation of harvesting equipment. Laterals are short. Fruit is very easy to harvest. Malahat is susceptible to RBDV.

Cowichan Tested as BC87-14-20 (Newburgh x Qualicum):
Cowichan appears to be a very promising option that offers an escape from RBDV infection. Its parent, the Newburgh variety, was introduced in 1929 from a cross made between Newman and Herbert. Newburgh is not a very productive variety and has small fruit, but it is resistant to both RBDV and root rot and it is relatively winter hardy. Cowichan was produced from a cross between Newburgh and Qualicum. It is productive, has large fruit size and good fruit quality and a vigorous growth habit. The variety is very quick to establish and produces a high yield after the first planting year. Cowichan plants tested in greenhouse trials showed some resistance to root rot, however when planted into root rot infected and poorly drained land, Cowichan did not stand up against root rot and should be considered as moderately susceptible to root rot. In the research plots, it was very vigorous, establishing quickly and producing yields that are higher than Meeker. Cowichan ripens about three days earlier than Meeker and its mid-point harvest was five days earlier than Meeker (Table 1). In field trials, although exposed to high pressure of RBDV for more than 10 years, it has tested negative to RBDV, while Meeker and other PNW varieties grown in the same field have shown very high infection rates. It can be assumed that Cowichan is resistant to RBDV. In large-scale growers' trials it has shown itself very suitable for mechanical harvesting. Cowichan fruit appears to be also suited for the fresh market, producing large firm fruit with a deep red colour, very good flavour and an aroma comparable to that of Tulameen and Chilliwack. Plant growth is very vigorous with an upright habit and large number of primocanes. Floricanes produce long and strong laterals. Fruit is spaced well apart along the laterals. It appears to be relatively susceptible to cane botrytis (*B. cinerea*) and spur blight (*Didymella applanata*).

Chemainus Tested BC89-33-84 (BC82-5-84 x Tulameen):
A mid-season processing and fresh market type that produces large-sized, dark, attractive berries with some resistance to fruit rot. The fruit is easy to harvest and in machine harvesting and growers' trials, it has machine harvested very well with excellent quality fruit that can be used for IQF. The fruit is glossy, large, and firm, perfect in shape with fine drupelets, and so is very suitable for IQF and 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. The selection appears to have some field resistance to root rot showing good growth in comparison to Meeker and Malahat. Chemainus is gaining popularity in the PNW with about 500,000 plants that have been already planted on large scale field tests.

Esquimalt Tested as BC89-2-89 (Comox x Glen Ample):
Esquimalt produces high yields of very large fruits that are firm and well adapted for fresh market and IQF. The selection is a cross between Comox and the Scottish variety Glen Ample. Fruit will ripen later than any other recommended PNW variety. Fruit is meaty and larger than Tulameen, light in color with large drupelets. The large fruit also have large drupelets that tend

to break when harvested too green. The plant is very vigorous, with strong spineless canes and long, strong upright laterals. It is not recommended for machine harvest. It is not resistant to RBDV. It is susceptible to cane botrytis (*B. cinerea*) and its reaction to root rot is unknown.

Sannich Tested as BC89-34-41 [(Algonquin x Chilliwack) x (Nootka x Glen Prosen)]: PARC's latest released cultivar, named in the fall of 2005. Sannich is a very productive cultivar that in most harvest years produced the highest yields. It is a fresh market or processing selection producing high yields with a fruit size that is slightly larger than Meeker. The excellent quality fruit are firm with a medium gloss, fine drupelets and a very pleasant sweet flavor that is comparable to Tulameen. The canes are spineless with laterals that are short and bend easily without breaking and so are able to carry the high yield. In grower's trials, the fruit appeared to release well from the receptacle and to harvest well mechanically. This selection, although exposed to high pressure of RBDV for many years, has been slow to show RBDV infection. It was released because of its productivity, suitability for machine harvesting and exceptionally high fruit quality. It produces medium-sized, firm and very sweet fruit that might be suited for specialty fresh fruit markets.

BC90-6-2 (BC86-41-15 x BC83-15-15):
BC90-6-2 was selected from a cross between a root rot resistant *R. strigosus* derivative and a selection from a cross between Comox and Algonquin. We have noted it for its short internodes, compact plant habit, extremely late production season and its very large, meaty fruit. Fruit is round, firm and dark red in color which makes BC90-6-2 suited also for processing. It machine harvests very well, producing high yields of dark, firm fruit. It is also suited for the late fresh market due to its long harvest duration, late producing period and large fruit. Hand harvesting of unripe fruit might be difficult. The dwarf growing habit of the plant might allow growing it with minimum support system. This will be tested in the coming years.

New selections for growers' trials:

BC87-11-33 (Latham x Qualicum)
This selection was identified for its high field resistance to root rot. This selection is as productive as Meeker and its fruit is comparable to that of Meeker. It is easy to harvest and might be suited for mechanical harvesting. Fruit is glossy, dark, and a bit soft and has fine drupelets. Plants are vigorous. It has tested positive to RBDV in 2005for the first time.

BC90-8-11 (BC86-41-15 x Qualicum)
This is a second backcross from a *R. strigosus* Dalhousie Lake 4 clone. It produces a large, mid-to-late season crop that is most suited for the fresh market but also might be acceptable for processing. The fruit is conical, large and meaty, firm and very attractive. The plant has an upright habit and fruit is well spaced and presented on the laterals.

BC90-8-20 (BC86-41-15 x Qualicum)
A productive mid-season selection that produces fruit that is light 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. It is resistant to aphids and might also be resistant to the resistance-breaking biotype of aphid.

BC90-11-44 (Algonquin x Qualicum)
This is a very productive selection that produces over an extended harvest season. The attractive fruit is large size, glossy and firm with very fine drupelets. It is easy to harvest and preformed well in mechanical harvesting trials.

The fruit is suited for processing, IQF and fresh markets. This selection is not resistant to RBDV and relatively susceptible to root rot.

BC92-5-47 (Kitsilano x BC86-40-6)
BC92-5-47 is a productive mid size fruit selection that is a third back cross from the *R. strigosus* Dalhousie Lake 4 clone that preformed well in MH trials and is yet to be tested on larger scales. The fruit is dark, firm, round shaped and with fine drupelets which it suited for IQF. Fruit color is dark as Meeker and tends to be dull with low gloss. It is not resistant to RBDV and its reaction to root rot is unknown.

BC92-6-41 (Chilliwack x BC86-41-15)
This selection was identified for its high field resistance to root rot. It is a second back cross from the *R. strigosus* Dalhousie Lake 4 clone. This source is not known to be present in any other cultivar. BC92-6-41 produces high yields of fruit that are easy to harvest. Fruit is conical and non-glossy, with a medium red that might be too light for processing. It keeps good size and productivity and has a long harvesting season. Limited numbers of plants for trials are available for planting on root rot infected areas for the 2006 season.

BC96-21R-56 [(Tulameen x *R. strigosus*) x (Meeker x (Glen Moy x Comox))]
This selection is a first 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 harvest trials it preformed very well, producing firm, not overripe, dark fruit comparable to Willamette in color. Fruit size averages about 4 g, which is larger than Meeker. The fruit is round, meaty, glossy and has large drupelets. It will be propagated for additional testing.

BC96-22R-55 [(Tulameen x *R. strigosus*) x (Cherokee x Qualicum)]
This selection is a first 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, large-sized (exceeding 5 g in size). 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. The harvest season of this selection starts about one week after Meeker's season and is short and concentrated.

BC96-37-1 [(Tulameen x *R. strigosus*) x Kitsilano]
This selection is a first back cross from *R. strigosus* from Lake George, Minn. It produces a high yield of dark fruit that is suited for processing and mechanical harvesting. Fruit is small to midsize and round in shape with fine drupelets that make it suited for IQF, too. The fruit color is as dark as Meeker.

BC97-30-3 (Qualicum x Willamette)
In the machine harvesting trial, this selection harvested very well. The fruit size is larger and darker in color than Meeker; the fruit is firm with small, fine drupelets. The fruiting season is similar to that of Meeker. It is not resistant to RBDV.

A limited number of plants from this list will be available for trials from Sakuma Bros. in Burlington, WA., Tel.: (360) 757-6611, Ken M. Spooner Farms, Tel.: (253) 845-5717 and from PARC Agassiz (604)796-2221. You are encouraged to plant and test some of these experimental trial selections.

Table 1. Machine harvest evaluation of PARC selections and cultivars.

Clone	Yield	Harvest ability	Fruit color	Comments
Cowichan	High	Good	Light	RBDV Resistant
Chemainus	High	Very Good	Dark	Excellent quality IQF
Qualicum	High	Pour/Good	Very Light	Lots of green fruit
Malahat	Medium	Very Good	Dark	Handpick/MH
Meeker	Medium	Good	Dark	
Sannich	Very High	Very Good	Light	Excellent quality IQF
Tulameen	Medium	Good	Very Light	
Willamette	Low	Very Good	Very dark	
BC90-6-2	High	Good	Very dark	Good quality
BC90-11-44	Very High	Pour/Good	Light	Large fruit, IQF
BC92-5-47	High	Good	Dark	Fine drupelets
BC96-21R-56	Low	Very Good	Dark	Round dark berry
BC96-22R-55	Low	Good	Dark	Strong laterals
BC96-37-1	High	Good	Dark	Fine drupelets, small berry
BC97-30-3	Low	Very Good	Dark	Excellent, fine drupelets
BC97-30-27	-	Good	Light	Vigor, no damage

Table 2a. Yield, fruit weight, harvest season and harvest ease of raspberry cultivars and selections planted in 2001 and harvested in 2005, Abbotsford, BC

Clone	No. Plots	Total Yield (kg/hill)	Marketable Yield (tons/ac)	Early Yield[1] (%)	Fruit Weight (g)	Fruit Rot (%)	5% Harvest (Date)	50% Harvest (Date)	95% Harvest (Date)	Harvest Duration (Days)
2001 Planting										
87-12-11	1	5.19	8.32	2.2	3.62	5.5	30-Jun	16-Jul	05-Aug	37
90-2-45	2	5.77	9.24	0.5	4.20	4.2	05-Jul	19-Jul	08-Aug	35
90-5-30	1	5.51	8.82	5.9	4.75	8.3	28-Jun	11-Jul	30-Jul	33
90-6-2	3	5.04	8.07	10.8	4.39	4.9	25-Jun	12-Jul	10-Aug	47
90-8-20	4	4.32	6.92	2.4	5.20	3.7	30-Jun	10-Jul	29-Jul	30
90-11-44	3	3.29	5.26	4.3	4.25	4.6	29-Jun	12-Jul	05-Aug	39
92-4-29	1	4.78	7.66	7.8	3.51	4.0	27-Jun	13-Jul	10-Aug	45
92-5-1	2	5.01	8.02	7.5	4.28	5.2	28-Jun	10-Jul	01-Aug	35
92-5-47	3	4.13	6.62	9.1	3.76	5.3	26-Jun	10-Jul	03-Aug	39
92-9-39	2	3.11	4.98	10.7	4.91	7.6	26-Jun	10-Jul	03-Aug	39
93-9-40	2	5.93	9.51	7.8	4.83	3.2	27-Jun	10-Jul	30-Jul	34
93-9-48	3	3.96	6.34	0.9	3.73	5.3	03-Jul	17-Jul	06-Aug	35
96-21R-56	2	2.96	4.74	17.6	3.94	3.7	24-Jun	07-Jul	27-Jul	34
96-22R-55	2	3.50	5.61	0.0	5.24	8.3	05-Jul	16-Jul	03-Aug	30
96-37-1	1	4.22	6.76	0.0	2.68	6.2	08-Jul	26-Jul	13-Aug	37
97-27-6	1	4.50	7.21	24.5	4.37	5.2	23-Jun	06-Jul	01-Aug	40
97-27-90	1	6.94	11.12	23.4	4.16	4.2	23-Jun	06-Jul	31-Jul	39
97-29-43	1	7.48	11.98	6.6	4.39	3.6	27-Jun	09-Jul	02-Aug	37
97-29-71	1	6.16	9.87	4.7	3.68	6.7	29-Jun	15-Jul	08-Aug	41
97-30-3	1	4.18	6.69	10.4	3.74	2.2	26-Jun	08-Jul	01-Aug	37
97-38-1	1	3.68	5.90	14.4	3.70	5.9	25-Jun	09-Jul	13-Aug	50
WSU1112	2	3.53	5.66	0.0	4.38	8.4	20-Jun	03-Jul	25-Jul	36
C. Delight	1	4.79	7.67	0.0	5.49	13.8	02-Jul	13-Jul	29-Jul	28
Chemainus	2	4.01	6.42	5.5	3.21	2.9	29-Jun	14-Jul	04-Aug	38
Cowichan	3	6.33	10.15	2.7	4.80	5.3	30-Jun	13-Jul	31-Jul	33
Esquimalt	2	5.12	8.21	2.1	4.29	4.6	02-Jul	13-Jul	04-Aug	34
Malahat	4	5.04	8.08	29.7	4.08	4.0	22-Jun	05-Jul	30-Jul	39
Meeker	5	4.11	6.58	5.0	3.21	3.7	29-Jun	11-Jul	28-Jul	30
Qualicum	4	5.52	8.84	5.4	5.42	4.9	29-Jun	10-Jul	31-Jul	34
Sannich	2	7.09	11.35	0.5	3.10	3.4	02-Jul	15-Jul	05-Aug	36
Tulameen	4	4.56	7.31	0.8	3.96	7.9	03-Jul	19-Jul	15-Aug	44
Willamette	1	2.20	3.53	27.6	2.87	4.3	05-Jul	19-Jul	16-Aug	43
LSD[4]		1.17	1.87	6.9	0.72	3.7	3	4	5	5

see foot notes on Table 1b

Table 2b. Yield, fruit weight, harvest season and harvest ease of raspberry cultivars and selections planted in 2002 and harvested in 2005, Abbotsford, BC

Clone	No. Plots	Total Yield (kg/hill)	Marketable Yield (tons/ac)	Early Yield[1] (%)	Fruit Weight (g)	Fruit Rot (%)	5% Harvest (Date)	50% Harvest (Date)	95% Harvest (Date)	Harvest Duration (Days)
2002 Planting										
87-3-37	1	2.29	3.66	0.0	2.64	2.0	01-Jul	12-Jul	23-Jul	23
87-12-11	2	5.07	8.12	3.1	3.56	8.8	21-Jun	02-Jul	19-Jul	29
90-2-45	1	4.81	7.71	0.9	3.95	4.2	26-Jun	06-Jul	25-Jul	30
90-5-30	2	5.88	9.42	9.5	4.65	7.0	22-Jun	07-Jul	28-Jul	37
90-6-2	2	4.69	7.51	9.9	4.53	6.3	27-Jun	10-Jul	29-Jul	33
90-8-11	1	3.86	6.19	2.6	5.46	6.0	24-Jun	07-Jul	29-Jul	36
90-8-20	2	4.15	6.64	0.0	5.57	7.8	27-Jun	10-Jul	29-Jul	33
92-4-29	1	3.85	6.17	21.7	3.52	2.9	29-Jun	11-Jul	30-Jul	32
92-7-43	1	4.77	7.65	0.0	2.93	15.3	30-Jun	11-Jul	30-Jul	31
92-9-39	2	3.90	6.24	13.4	5.86	9.3	30-Jun	11-Jul	30-Jul	31
92-25-3	1	4.91	7.86	19.9	3.80	6.8	27-Jun	10-Jul	30-Jul	34
93-9-40	1	6.42	10.29	5.9	4.77	5.1	24-Jun	07-Jul	31-Jul	38
93-15-3	1	6.89	11.04	7.0	4.57	8.3	24-Jun	06-Jul	31-Jul	38
94-13-2	1	3.91	6.27	7.9	3.64	7.4	30-Jun	13-Jul	31-Jul	32
96-19R-20	1	3.98	6.37	2.6	4.32	2.7	04-Jul	14-Jul	01-Aug	29
97-25-58	1	4.56	7.30	12.2	4.75	5.1	30-Jun	14-Jul	06-Aug	38
97-27-17	1	2.30	3.69	2.6	3.58	8.9	30-Jun	17-Jul	06-Aug	38
97-29-29	1	4.13	6.61	0.0	4.02	9.7	02-Jul	14-Jul	08-Aug	38
97-29-35	1	4.90	7.84	7.2	4.35	9.4	30-Jun	17-Jul	08-Aug	40
97-30-49	1	4.34	6.95	7.9	4.10	3.2	30-Jun	14-Jul	09-Aug	42
C. Delight	1	3.58	5.73	1.6	5.29	13.8	05-Jul	01-Aug	12-Aug	39
Coho	1	3.04	4.87	32.8	3.13	8.9	03-Jul	21-Jul	13-Aug	42
Cowichan	3	6.49	10.39	2.4	5.14	6.8	04-Jul	21-Jul	13-Aug	41
Malahat	2	6.01	9.62	17.9	4.43	6.3	08-Jul	23-Jul	15-Aug	39
Meeker	1	6.21	9.95	3.4	3.82	6.6	20-Jun	07-Jul	16-Aug	58
Qualicum	2	4.60	7.37	1.5	4.69	7.7	26-Jun	18-Jul	17-Aug	53
Tulameen	2	2.89	4.63	2.3	4.23	9.3	06-Jul	30-Jul	18-Aug	44
LSD[4]		1.17	1.87	6.9	0.72	3.7	3	4	5	5

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 June 29, 2005

[2]Late Yield harvested after July 25, 2005

[3]Harvest Ease was rated on each harvest: 1=easy, 5=hard

[4]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 size, % fruit rot and harvest season of PARC released cultivars as compeered to Meeker (Abbotsford 1995-2004).

Clone	Yield (Tons/acre)	Yield (% of Meeker)	Fruit wt (g)	Fruit rot (%)	Harvest date		Harvest duration (days)
					5%	50%	
BC89-34-41	9.31 a	144	3.0 e	2.3 c	7 July a	21 July b	33 ab
Chemainus	7.26 cd	112	3.6 d	2.3 c	5 July c	18 July b	33 ab
Cowichan	7.10 cd	110	4.2 c	4.4 b	3 July d	15 July c	30 c
Esquimalt	9.02 a	140	4.6 a	3.8 b	7 July a	23 July a	32 b
Malahat	6.73 d	104	4.1 c	2.6 c	30 June e	12 July d	33 ab
Qualicum	8.31 b	129	4.4 b	5.2 a	5 July c	19 July b	29 d
Tulameen	7.75 bc	120	4.4 b	5.2 a	6 July b	19 July b	35 a
Meeker	6.46 d	100	3.0 e	1.6 d	6 July b	20 July b	29 d

Means separation within columns by Student-Newman-Keuls multiple range test, P=0.05.

Table 4. Fruit traits of raspberry cultivars and selections harvested in 2005, Abbotsford, BC.

Clone	Firmness (g/cm^2)	Soluble Solids Concentration (%)	Postharvest Fruit Rot After 48 hours (%)
90-11-44	131	11.2	23.9
90-2-45	131	10.1	39.2
90-5-30	190	10.1	27.2
90-6-2	104	8.9	13.9
90-8-20	132	11.1	11.2
92-4-29	78	9.5	25.0
92-5-1	57	9.6	7.9
92-5-47	80	10.3	15.0
92-9-39	165	9.0	20.0
93-9-40	107	10.9	20.6
93-9-48	105	10.0	25.6
94-13-2	126	9.6	16.7
96-19R-20	104	11.7	
96-21R-56	106	10.5	13.9
96-22R-55	184	10.4	
96-37-1	114	10.8	
97-27-6	207	10.3	24.4
97-27-17	328	11.6	
97-29-35	181	11.2	28.3
97-29-43	221	11.1	17.0
97-29-71	158	11.3	37.8
97-30-3	208	8.9	10.6
97-30-49	372	10.5	
Chemainus	123	12.0	16.7
Cowichan	87	10.4	19.4
Esquimalt	125	10.5	22.9
Malahat	113	10.9	16.1
Meeker	98	10.7	15.0
Qualicum	133	11.9	16.7
Saanich	96	11.4	16.7
Tulameen	173	12.0	
LSD[1]	130	1.5	11.5

[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: 2001 **Current Year:** 2006-2007 **Terminating Year:** 2009

Personnel:

Chaim Kempler (Research Scientist), Brian Harding (Technician) and Hugh Daubeny (Retired).
Pacific Agri-Food Research Centre, Agriculture and Agri-Food Canada,
PO Box 1000, Agassiz, BC, Canada V0M 1A0
Tel.: (604) 796-2221 Ext. 224; Fax: (604) 796-0359 ; Email: kemplerc@agr.gc.ca

Project Description:

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

Justification:

The Agriculture and Agri-Food Canada (AAFC) breeding program supports the berry industry throughout the Pacific Northwest (PNW) and produces new berry varieties that enhance production. Of particular importance to the industry is the development of cultivars displaying disease and pest resistance, such as resistance to raspberry bushy dwarf virus (RBDV), root rot, fruit rot and raspberry mosaic virus (RMV). The RMV complex can be a limiting factor in raspberry production but can be simply controlled by introducing resistance to its aphid vector. Reaction to the aphid vector *(Amphorophora agathonica)* of the RMV is used by the Pacific Agri-Food Research Centre (PARC) program as a primary screen in the seedling stage. All the cultivars that are released from this program are resistant to the common biotype of *A. agathonica*. A resistance-breaking biotype of *A. agathonica* has been found in North America but is not causing problems, as it does not colonize very well on resistant cultivars and is not yet a vector of RMV. Raspberry bushy dwarf virus (RBDV) causes symptoms that adversely affect fruiting and growth in susceptible raspberry cultivars and selections. The combination of RBDV with raspberry mosaic virus (RMV) has been shown to be particularly detrimental to growth and fruiting. The most common strain of the RBDV virus has been controlled by breeding for resistance. Of cultivars released in the past, Haida and Nootka, and Chilcotin are resistant to RBDV. The recently released Cowichan (BC87-14-20) has given some hope to the industry that there is a cultivar that is suitable for mechanical harvesting and that escapes RBDV. More than half a million Cowichan plants have already been planted across the PNW since its release. The plantings are evaluated by the growers for production and suitability to their operation. The advance testing shows that Cowichan meets expectations; Cowichan escapes RBDV, machine harvests very well, is high yielding, stands up well to spring frost and winter injury and establishes very well in the first year after planting. It produces good quality fruit with good flavor that is also suited for the fresh market. However, although it grows very vigorously, it lacks root rot resistance needed for success in infected soils, or heavy and poorly drained soils. Chemainus (BC89-33-84), another recently released variety has more than 300,000 test plants grown across 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. Selection BC89-34-41 that has been recently named Sannich has been extensively planted throughout the PNW with more than 200,000 plants; this selection 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 very slow to become infected with RBDV. Its reaction to root rot is unknown.

The PARC breeding program is using selections of *R. strigosus* as new sources of resistance to the root rot caused by *Phytophthora fragariae.* F1 to F3 are tested and used in back crosses to incorporate resistance into cultivars and advance selections. BC90-19-34 is a hybrid between Tulameen and *R. strigosus*. It has shown resistance to root rot under field conditions in Puyallup and also appears to be suited for mechanical harvesting and processing. It has been already planted in growers' trials and if named, it will be the first cultivar release from this source of *R. strigosus* collected from Lake George, Minnesota.

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 BC, winter hardiness is a primary concern in the selection procedure. Unusually cold test winters that occur during the selection years allow for selection of more hardy genotypes. Selections that go dormant early and break dormancy late are probably the most desirable to select for cold hardiness.

The PARC breeding program has broadened its genetic base by drawing on different sources. Parents derived from various species are used. Furthermore, germplasm from other breeding programs around the world is used. This germplasm is tested and used to incorporate desirable traits into PARC selections. Also, a wide range of wild species are used. Three cultivars released from the program (Tulameen, Qualicum and Malahat) have the black raspberry, *Rubus occidentalis* L., in their derivation. In addition, Malahat is a descendant of *R. phoenicolasius* Maxim. Some of the potential cultivars that are now in growers' trials contain *R. occidentalis* in their derivation. Kitsilano has *R. crataegifolius* in its derivation, while BC90-6-2, BC90-8-11, BC90-8-20, and BC92-6-41 have the Dalhousie Lake selection of *R. strigosus* Maxim. in their derivations. BC90-19-34 is F1 cross between Tulameen and the 'Lake George' selection of *R. strigosus*, and BC90-2-45 has Kanata B in its derivation.

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

Objectives:
To develop red raspberry selections, stressing suitability for machine harvesting, dark fruit, winter hardiness, resistance to root rot, resistance to divergent aphid biotypes, and resistance to RBDV. Specific goals include:
-The fast release of potential cultivars to propagators for multiplication for testing on growers' fields.
-Resistance to pollen infection from the raspberry bushy dwarf virus (RBDV).
-Resistance or tolerance to root rot (*Phytophthora fragariae)* and lesion nematodes.

-Manageable plant habit that is suitable for machine harvesting and produces high yields.
-Superior fruit quality, including good flavour, size, firmness, ease of harvest, and rot resistance.
-Winter hardy plants that withstand low temperatures and desiccating winds throughout winter months, and/or late breaking dormancy.
-Aphid resistance, which controls the Raspberry Mosaic Virus Complex (RMVC).
-Dark fruit for processing that exhibits high acidity and high soluble solids content.
-Resistance or tolerance to cane diseases (such as spur blight, cane *botrytis* and cane spot), spider mites, bacterial blight, crown gall and to leaf diseases such as rust and powdery mildew.
- Adequate replacement cane production.

Procedures:

~~*Experimental Details:* This~~ will involve ~~the harvest~~ of sound and rotten fruit, the assessment of ease of harvest, 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 in the test plots will include 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)*. Any winter damage will be recorded relative to the standard cultivar Meeker.

Advanced selections will also be used in further breeding to develop a broad base of resistance.

Activities:

- Create 2006 crossing blocks – cross selections that stand up to root rot under field conditions with cultivars and potential cultivars that have RBDV resistant parents in their derivation and therefore might be resistant.
- Evaluate the seedling population planted in 2004.
- 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 potentially selections to the propagators.
- Supervise distribution of advanced selections to North American propagators and growers and subsequently monitor their performance.
- Evaluate Cowichan, Esquimalt, Chemainus, BC89-34-41 and other selections on large growers' trials.
- Conduct collaborative research with Robert R. Martin, USDA-ARS, Corvallis, Mike Bernardy, PARC Summerland and Ron Wilen, University Collage of the Fraser Valley to develop a marker assistant process to identify RBDV resistance at the seedling stage. When available, this procedure can shorten the usual 10 years or more that it takes for testing of resistance into a simple screening process that can be done before the seedlings are planted in the field.

Anticipated Benefits and Information Transfer:
Six out of the twelve research priorities determined by the Red Raspberry Commission are addressed in the objectives of the PARC breeding program and are of major importance within this research proposal. It is well established that, when possible, breeding for resistance is the most sustainable and preferable way to address industry concerns and needs. The PARC program emphases the development and release of RBDV resistant cultivars (such as Cowichan) and cultivars that will withstand *Phytophthora* root rot pressure (Cowichan, Chemainus, BC90-19-8 and 92-6-41). All PARC releases are resistant to aphids, which cause insects harvest contamination. Many of the PARC releases are suited for the fresh market, extend the harvest season and are tested for both pre- and post-harvest fruit rot.
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 the latest releases and other 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: Amount requested from the WRRC for FY 2005/2006: <u>$US 4,000.</u>** ($CD 5,100)

Other industry partners and level of funding requested:

Raspberry Industry Development Council (RIDC)	$CD 15,000
Lower Mainland Horticultural Improvement Association (LMHIA)	$CD 4,000

AAFC MII commitment (approved-conditional to industry funding) $CD 44,818

***Resource commitments* by**	**MII**	**Industry(Cash)**	**Industry(in-kind)**
Salary	25,000	-	-
Benefits	5,000	-	-
Student salary	-	17,960	-
Travel	-	1,000	-
Operating	5,565	1,700	-
RIDC technical coordinator			2,500
RIDC use of growers land			5,000
RIDC plant propagation for growers trials			2,250
WRRC " " for the Abbot. Site			900
RIDC Virus testing			4,188
RIDC soil testing			480
WRRC trials 04/05 planting			2,200
WRRC trials 05/06 planting			1,700
WRRC technical coordinator			1,500
Admin cost on industry in-kind	3,108	-	-
Admin cost (15%)	5,845	3,140	-
Total	**$ 44,818**	**$ 23,800**	**$ 20,718**

Budget Summary

Contribution		
RIDC	15,000	
WRRC (US$4,000)	4,800	
LMHIA	4,000	
Industry in-kind	20,718	
Total industry (Cash + in-kind)		**44,318**
AAFC-MII	~~44,318~~	
Total for project		**90,036**
Administration cost (AAFC-PARC)	12,093	
Total funds available to the program		**57,225**

NEW PROJECTS

Project No:

Title: ***DEVELOPMENT OF VALUE-ADDED DRIED RASPBERRY PRODUCTS***

Year Initiated 2006 Current Year 2006-2007 Terminating Year 2007

Personnel: Carter D. Clary, Ph.D. Assistant Professor
Horticulture and Landscape Architecture
Washington State University
P.O. Box 646414, Pullman, WA 99164-6414
509/335-6647 tel 509/335-8690 fax
cclary@wsu.edu www.mivac.com

Justification:

Dehydration offers a means of preserving foods in a stable and safe condition, providing a shelf life longer than that of fresh fruits and vegetables. Most fruits are dried in heated air dryers, however the heat required to obtain acceptable final moisture content changes the character of the dried product. Freeze drying has historically represented the alternative to heated air drying. The low temperature used in this process preserves fresh character, but the cell structure of fruits is compromised resulting in loss of color and nutritional value. The process is also expensive because of the slow rate of dehydration (Flink, 1975).

Microwave vacuum dehydration offers the opportunity to dry delicate fruits without degradation of shape, color and flavor. Use of continuous wave microwave energy applied in low-pressure conditions provides distinct benefits of low temperature dehydration that preserves fresh character including color, flavor, volatile aromas and nutritional value. Dried fruits such as strawberries exhibit a brilliant red color; berries have a crunchy, fresh taste; grapes maintain a tangy, fresh flavor and bright color – all accomplished without the use of preservatives (Sham, et al., 2001). Petrucci and Clary (1989) evaluated the nutritional profile of fruits dried by various methods. Fruit dried using microwave vacuum dehydration maintains most of their original nutritional value. This includes vitamins sensitive to heat that are denatured and lost in conventional heated air dehydration.

Food processing in Pacific Northwest occupies a strong position in the food production system. However, foreign processors are increasing freeze drying capacity to compete with the Pacific Northwest in domestic and international markets. Raw material costs and cheap labor from off-shore competition is eroding domestic market share. This can result in a loss of jobs in the agricultural and processing industries of Washington, Oregon and Idaho.

The agricultural areas of the Pacific Northwest are growing berries and fruits that are utilized by the fruit processing industry. The solution is for a current processor or processors who are actively participating in these markets to apply drying methods and equipment to utilize the fruit (both fresh and frozen) at a lower cost than freeze-drying methods. This focus of this project will be to develop the processing parameters and produce prototypes of specific raspberry products using microwave vacuum dehydration.

Objectives:

1. Work with the Commission to develop prototype samples of dried raspberry from fresh and dehydro-frozen fruit.
2. *Distribute dried raspberry samples to food companies for evaluation and acceptability.*

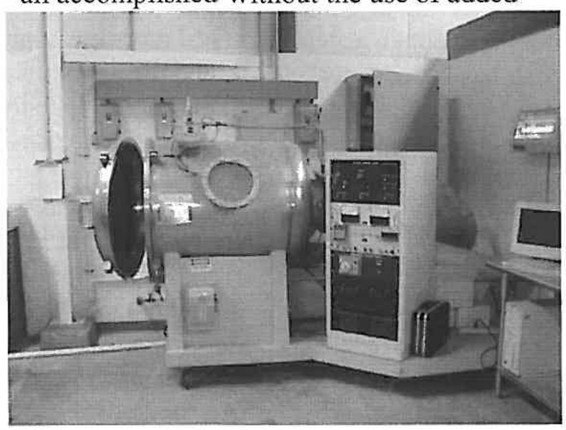
3. *Identify collaborators for commercialization of this technology.*
4. If successful, evaluate the subsequent commercialization of necessary equipment in new project in 2007.

Procedures:

Microwave vacuum dehydration offers a new and unique way to dry food products. Microwave energy heats the fruit uniformly, inducing vaporization from all parts of the product simultaneously. The result is rapid dehydration. Since vaporization takes place in a vacuum:

- *the process temperature is low,*
- *a very low final moisture content can be attained in 2 hours or less, and*
- *fresh color, flavor and nutritional value are preserved (Clary, et al, 2005, Clary and Ostrom, 1995, Petrucci and Clary, 1989, Petrucci, et al, 1993).*

The process creates a porous texture in the dried product that contributes to preservation of its original shape and size. Use of microwave in low-pressure conditions provides distinct benefits compared to field, hot air, and freeze-drying methods. Dried fruits such as strawberries exhibit a brilliant red color; bananas have a crunchy, fresh taste; grapes maintain a tangy, fresh flavor and bright color; and apple slices maintain an "airy" texture and a bright white flesh color – all accomplished without the use of added preservatives.



Research conducted at California State University, Fresno has proven the concept of continuous MIVAC[R] *processing and dehydration of many fruits and vegetables on a prototype system. A batch type microwave vacuum dehydration unit has been re-located to the Food Processing Laboratory at WSU Pullman for testing the process and product development. This system consists of a microwave power supply, controls and a vacuum vessel for processing the fruits.*

Fresh and dehydro-frozen raspberries will be dried in the batch microwave vacuum dryer. After each test, the dried samples will be evaluated for appearance and flavor. Dehydro-freezing will be evaluated to reduce processing cost. Fruit will be dried to ~50% (wb) and individually quick frozen. If successful, this method of preparation will make it possible to develop a supply of raw product on a year-round basis.

Treatments will include:

- *Variety (if appropriate)*
- *Dehydro-freezing (time and temperatures)*
- *Microwave power level (specific energy)*
- *Time of exposure to microwave power*

Specific initial and final moisture content will be established in consultation with the Commission. Finished products will be provided for assessment of commercial application.

Anticipated Benefits and Information Transfer:

The agricultural areas of Washington are growing berries and fruits that can be utilized as ingredients by the cereal and other food industry. An ingredient manufacturer is needed to economically dry these products in such manner that preserves their characteristics. If this processing system could utilize dehydro-frozen fruit in addition to fresh, fruit could be made available for drying year-round.

Food processing in Washington State occupies a strong position in the food production system. Agricultural commodities from more than two million farms and ranches are processed through 20,000 processors, which in turn sell an array of processed products to more than one-half million food wholesalers and retailers (WSLI, 2001). At the same time, foreign processors are increasing capacity to compete with Washington State in domestic and international markets.

Our intent is to work with the Raspberry Commission to determine the specifications for dried raspberry products. The treatments and procedures outlined in this proposal may be altered based on input from the industry.

Budget:

Amount allocated by Commission for previous year: $-0-

Request for FY 2006-2007

Salaries[1/]	$ 7,759
Time-Slip	$ 4,500
Operations (goods & services)	$ 2,000
Travel[2/]	$ 2,000
Projected Needs	
Meetings	
Other	
Equipment	
Employee Benefits	$ 3,133
Total	$19,392

Other support of project:

This proposal was prepared at the request of the Executive Director of the Washington Raspberry Commission.

[1/] One month of Carter Clary's salary. Timeslip wages for summer student support.

[2/] Three trips to west side.

Current & Pending Support

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

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
	Current:				
Clary	Washington Technology Center and Tree Top Inc	$20,000	1/05-12/05	5%	MIVAC production of fresh and frozen prototype fruits for cereal inclusions
Clary, Cavalieri, Durfey, Ball, Folwell	WSDA	$333,000	7/05-6/06	10%	Evaluation of selective mechanical harvesting of asparagus
Clary, Tang	IMPACT Center	$23,748	8/05-6/06	10%	Improving value and quality of dried fruits using microwave vacuum technology
	Pending:				
Clary	Washington Technology Center and Tree Top Inc	$20,000	1/06-12/06		MIVAC production of fresh and frozen prototype fruits for cereal inclusions (Phase II)
Clary, Fellman	IMPACT Center	$$44,987	7/06-6/08		Improved quality attribute retention of high-value horticultural crops via microwave vacuum drying technology

References:

Clary, C.D., S. Wang and V.E. Petrucci. 2005. Fixed and incremental levels of microwave power application on drying grapes under vacuum. J. Food Science. 70(4) pp 344-349.

Flink, J. 1975. *The retention of volatile components during freeze drying: a structurally based mechanism.* IN Freeze drying and advanced technology. Eds. S.A. Goldblith, L Bey and W.W. Rothmayr. Academic Press, London, England.

Petrucci, V.E. and C.D. Clary. 1989. Microwave Vacuum Drying of Food Products. EPRI Report CU-6247. Electric Power Research Institute, Inc. 4312 Hillview Avenue. Palo Alto, CA 94304.

Sham, R.W.Y., C.H. Scaman and T.D. Durance. 2001. Texture of vacuum microwave dehydrated apple chips as affected by calcium pretreatment, vacuum level and apple variety. J. Food Science. 66:9, 1341-1347.

Washington State Labor Information. 2001. http://www.wa.gov/esd/lmea/sprepts/indprof/foodp.htm

2006-2007 COMMISSION RESEARCH PROPOSAL FORMAT[a/]

Project No:

Title: New Strategies to Replace Nemacur in Red Raspberries for Plant Parasitic Nematode Control

Year Initiated 2006 Current Year 2006-2007 Terminating Year 2009

Personnel:

Principal Investigator: 1) Dr. Ekaterini Riga, Nematologist, Washington State University, IAREC, 24106 N. Bunn Rd., Prosser, WA 99350. Phone:509-786-9256 Fax:509-786-9370, E-mail: riga@wsu.edu; and **Dr. Jack Pinkerton**, USDA-ARS Horticultural Research Lab., Northwest Center for Small Fruit Research, 3420 NW Orchard Ave., Corvallis, OR 97330. Phone 541-750-8784, Fax 541-750-8764, E-mail: pinkertj@science.oregonstate.edu

Cooperators:

1)**Dr. Tom Walters**, Small Fruits Physiologist, Washington State University, Northwest Washington Research and Extension Center, 16550 State Rte 536, Mount Vernon, WA 98273, Phone:360-848-6124, Fax:360-848-6159, twwalters@wsu.edu

2) **Dr. Tom Forge**, Agriculture & Agri-Food Canada; Pacific Agri-Food Research Centre; Agassiz, BC, V0M 1A0; Phone:604-796-8791,forgeta@em.agr.ca

3) **Mr. Harvey A. Yoshida and Lucas Schmidt**, Product Technology Specialists, Dow AgroSciences, 432 Aimes Drive, Richland, WA 99352, Phone:509-628-1368, Fax:509-628-2029, hyoshida@dow.com

4) **Dr. Christopher Ishida**, Field R&D Scientist, Valent BioSciences Co., O.O. Box 87160, Vancouver, WA 98687, Phone: 360-834-4457, christopher.ishida@valent.com

5) **Mr. Norman McKinley**, DuPont Ag Products, 4280 Montaigne Lane S., Salem, OR 97302, Phone: 503-370-9976, Norman.D.McKinley@USA.dupont.com

6) **Dr. Mel Grove,** ISK Biosciences Corp., 2237 Haden Road, Houston, TX 77015 Phone:713-393-3750, GROVEM@iskbc.com

7) **Mr. S. Sakuma,** Sakuma Bros., PO. Box 427, Burlington, WA 98233. Phone: 360-757-6611, steves@sakumabros.com

8) **Mr. Darryl Ehlers**, Lynden, Whatcom County Red Raspberry Grower

Justification:

Plant-parasitic nematodes are major pests of red raspberries worldwide. Symptoms associated with nematode infested soils are gradual and lead to general reduction in cane vigor and fruit production and quality. Nematodes feeding on the roots can modify root growth (produce necrotic lesions and root stunting), compete with the plant for carbohydrate, and predispose the plant to infection by other pathogens. In addition, dagger nematodes vector important viruses. In perennial crops, population densities of nematodes can build up from low levels to damaging levels during the plant lifetime. The three economically important nematodes for red raspberries are the lesion nematode, *Pratylenchus penetrans*, *Xiphinema bakeri,* and *X. americanum.* If root lesion nematodes left uncontrolled they will shorten the productive life span of an established raspberry field by 2 to 3 years, and dagger nematodes will weaken fields and reduce fruit quality and yield. These species are widespread throughout the region. Nemacur, the only post-planting nematicide registered for raspberry will not be available as of 2006. Therefore, a replacement is needed to protect the plants against the lesion nematode and the dagger nematodes. Oxamyl (Vydate) is a synthetic non-fumigant systemic nematicide and it has been tested in a wide variety of crops against lesion and dagger nematodes, and is registered for use on red raspberry in Canada. DiTera is a biologically derived natural product from the hyphomycete fungus *Myrothecium* spp.,

and it is composed primarily of proteins, sugars, and lipids. DiTera has been tested against a wide range of nematode species and it is shown good plant parasitic nematode control. Cordon is a 1,3 dichloropropene based fumigant that is applied through the water, at low concentrations to kill plant-parasitic nematodes. Fosthiazate (Nemathorin) has been used for nematode control of field crops and its efficacy is considered better than Nemacur. All of the above compounds will be tested in a red raspberry field with moderate to high nematode densities over a period of three years to evaluate their efficacy against nematodes and effect of berry yield.
Oregon State faces similar nematode related problems as Washington State. There is limited raspberry production in Idaho and problems related to nematodes have not been reported.
We will contact research to find a replacement for Nemacur for the control of plant parasitic nematodes effecting red raspberry production in the Pacific Northwest.

Objectives:

Evaluate the efficacy of post-plant applications of synthetic nematicides (Nemacur, Vydate, Cordon and Fosthiazate) and biologically based nematicides (DiTera) as replacement for Fenamiphos (Nemacur) against plant parasitic nematodes

This funding year all of the above chemicals will be tested.

Procedures:

A field experiment will be established in April 2006, in Lynden, WA. Soil samples will be collected from various established red raspberry fields in the fall of 2005 as the dagger nematode and the lesion nematode densities are high during fall. A field with moderate to high nematode densities will be used for our experimental trials. The experiment will be laid out in 3 adjacent rows. Plots will consist of 10 m of row in a randomized block experimental design with five replicates. Rates, treatments and application timing are listed below:

Treatments	Rates/	Oct-Nov/05	Apr/06	May/06	Jun/06
		Application dates			
Phenamiphos (Nemacur)	1 gal/acre	X			
Oxamyl (Vydate)	1 gal/acre		X	X	X
Cordon	100/200ppm	X			
Ditera	8 lb/acre	X	X	X	X
Fosthiazate	26 lb/acre		X		
Control					

Nemacur, Vydate, Fosthiazate, and DiTera will be applied in a 1 m band on the soil surface in the row. Material will be made applied as aqueous sprays and immediately watered in with irrigation or rain. Cordon will be injected into the irrigation water supply and applied through drip irrigation tapes laid on both sides of the row in the plots. The injection and irrigation system in these plots will be self-contained, i.e. not connected to the irrigation system in the field. Chemigation water will be delivered to saturate the rooting zone. Soil samples will be collected for nematode analysis in the fall and spring prior to any nematicide application, in mid-season and after harvest. Yield estimates will be made by harvesting and weighing fruit in each plot. Because the all materials are not registered for use in red raspberry, fruit will be destroyed. Nematicides will be applied and plant and nematode data will be collected for three years. In addition to materials listed above, other chemical and biological nematicides will be in trials, as they become available. Preliminary greenhouse test will access the effectiveness of the new compounds (Dr. E. Riga will perform these tests in her greenhouse. The Sakuma Bros will supply the tissue culture plants For greenhouse experiments. Several Red Raspberry fields have been surveyed for nematode densities. The best field has been chosen for our trials. Data will be presented as number of nematodes per 250 cc per treatment and berry weight per meter of row and lbs per acre. All data will be compared to the non-treated controls and analyzed using ANOVA.

Anticipated Benefits and Information Transfer:

We expect to find an appropriate replacement for Nemacur and to develop management strategies for controlling plant parasitic nematodes that affect red raspberry production in the PNW.

Results will be disseminated directly to the growers (E. Riga has an extension appointment in addition to her research appointment) and during annual Nematology meetings, industry meetings, field days, and through grower-oriented publications such as Capitol Press (OR) and Good Fruit Grower (WA). In addition, results will be published in peer-reviewed scientific journals.

Budget: Amount allocated by Commission for previous year: $ 0 / this is a new proposal

Request for FY 2006-2007

Salaries[1/]	3,432
Time-Slip	4,011
Operations (goods & services)	
Travel[2/]	500
Projected Needs	
Meetings	500
Other	
Equipment[3/]	
Employee Benefits[4/]	1,441 (42% for salary)
Employee Benefits[4/*]	441 (11% for Time slip)
Total:	10,325

Other support of project:

This proposal has been submitted to the pesticide commission and NCSFR for matching funds (please see current and pending support). Funding from the Commission is crucial for this project because: 1) funding of this project from other sources is pending; and 2) additional funding will ensure completion of the project without having to cut corners.

[1/] 0.10 RA grade II. The RA will assist T. Walters with field work. The Time Slip position will assist E. Riga will sample processing and nematode extraction and identification.

[2/] E. Riga is located in WSU, Prosser. She will travel to Lynden at last 3 times per year to assist with the field trial. The travel funds will cover part of the travel expenses (i.e. car rental, gas and accommodation) E. Riga is planning to attend the Society of Nematologists meeting and the funds requested will cover about ¼ of the expenses. She will present red raspberry data to other Nematologists working with small berry fruits from across the country.

[4/] The benefits rate for the RA position is 42%. The benefits rate for the Time slip position is 11%.

Current & Pending Support

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

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
	Current:				
	Pending:				
E. Riga, J. Pinkerton, et al.	NCSFR	36,864	2006-2009	20%	New Strategies to Replace Nemacur in Red Raspberries for Plant Parasitic Nematode Control
E. Riga	Washington State Commission on Pesticide Registration	11,000	2006-2009	10%	New Strategies to Replace Nemacur in Red Raspberries for Plant Parasitic Nematode Control

Project No: NEW – Prior Project Number: 13C-3419-3297

Title: Postemergence Canada Thistle Control in Red Raspberries

Year Initiated: 2006-07 **Current Year:** 2006-07 **Terminating Year:** 2007-08

Personnel:

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

Justification:

Canada thistle (*Cirsium arvense*) has long been weedy in western Washington. This perennial weed species frequently becomes established in perennial crop ground and, once established, is extremely difficult to control. Canada thistle spreads primarily by creeping perennial roots which grow through the row, by it is also easily spreads as root fragments through cultivation and by its plumed seed. The weed often will outlive the raspberry crop, is difficult to control in the break crop between raspberry plantings, so it generally remains a problem in the subsequent raspberry planting. Yet another difficulty with Canada thistle in raspberry is the physical interference to berry drop using machine harvesters, which may result in berry loss. Canada thistle also impacts harvest of hand-picked fruit, as any fruit picker with unprotected fingers can testify, and reduces the efficiency of hand harvest by making berries harder to find and pick.

It is important to gain new tools for controlling established Canada thistle in established raspberries. At the 2004 IR-4 food use workshop, Stinger was mentioned as potentially gaining registration for use in raspberry. I tested two products aimed at controlling Canada thistle, Casoron (dichlobenil, applied postemergence rather than during the dormant season) and Stinger (clopyralid, applied postemergence) at WSU Vancouver in 2001. Other berry studies I have conducted have shown that Stinger provides superior Canada thistle control, while the initial data from Vancouver study indicate that late spring/early summer applications of Stinger causes only slight injury to raspberry, and that a similar application timing for Casoron was also highly effective with no visible raspberry injury. Because the raspberry block at WSU Vancouver was quite thin due to extensive Phytophthora root rot infection, the plants were removed in fall, 2001 so no information is available concerning the effect of these products on primocane growth. Clearly, 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.

Objective: To test postemergence Stinger and Casoron for control of Canada thistle in established raspberries.

Procedures:

Plots will be established in 2005 in a Canada thistle-infested raspberry field near Mount Vernon. Herbicide applications will be made at two rates each for Casoron and Stinger and at two timings (early- and late-postemergence in late spring and early summer). Canada thistle control will be evaluated, as will herbicide effects on raspberry yield, berry size, and primocane growth.

Anticipated Benefits and Information Transfer:

If positive, data from this experiment will be used to support a new herbicide registration in raspberries for Stinger and to fine-tune the existing label for Casoron. The data resulting from these studies will be disseminated through extension bulletins and during grower meetings sponsored by extension faculty and the agricultural industry.

Budget:

Amount allocated to PI by Red Raspberry Commission for FY 2005-06: $ 7,000

	Requested 2006-07
Salaries	
A/P technician (Carl Libbey)	$ 1,000
Time-slip	500
Operations (goods & services)	250
Travel	
Projected needs[a]	150
Meetings	0
Other	0
Equipment	0
Employee Benefits	
A/P technician (37.5%)	375
Time slip (11%)	55
Total Request	$ 2,330

[a]Travel will be used for plot work at an off-station site near Mount Vernon, WA.

Other Support of Project:

Herbicides are typically provided by herbicide manufacturers.

Project No: NEW

Title: Using an AlternateYear Red Raspberry System to Aid Perennial Weed Control

Year Initiated: 2006-07 **Current Year:** 2006-07 **Terminating Year:** 2008-09

Personnel:

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

Justification:

Perennial weed species generally become more important the longer raspberry blocks are left in production. Field horsetail (*Equisetum* spp.), quackgrass (*Elymus repens*), broadleaf dock (*Rumex obtusifolius*), dandelion (*Taraxacum officinale*), Canada thistle (*Cirsium arvense*), and hedge bindweed (*Calystegia sepium*) have long been weedy in western Washington. These weeds frequently become established the first few seasons on a new raspberry block, when raspberry plants are small and not as competitive. If not controlled when young, perennial weeds become increasingly difficult to kill, ballooning herbicide and labor costs and becoming a major factor in reducing the longevity of raspberry plantings. This is particularly a problem in organic blocks where few herbicides are registered, and of those that are, only top-kill of weeds is possible. But even in conventionally-produced raspberries, few herbicides provide reliably good perennial weed control without the risk of unacceptably high crop injury.

A method potentially allowing for control of established perennial weed species in established raspberries may be to switch to an Alternate Year (AY) pruning system from the standard Every Year (EY) system. One of the difficulties of controlling perennial weeds in raspberries with existing herbicides is the presence of primocanes—treatments used to kill weeds may also injure the primocanes which in turn affects next season's fruiting. It is clear that when the foliage of a perennial weed is removed as it is produced, reductions in root mass occur which should at least decrease the vigor of those weeds, or if employed over the course of a full growing season, hopefully eliminate them altogether. Under an AY system, floricanes would be left to bear fruit while foliage of weeds and primocanes are removed using one of several contact herbicides currently available. Floricanes should continue to feed the raspberry root system during the bearing year, which should put the raspberry plants at an advantage compared to the perennial weeds. Spent floricanes will then be removed during winter dormancy. During the off-year, primocanes will be allowed to grow and selective herbicides used to suppress weed growth, resulting in a net reduction in the impact of perennial weeds in raspberries.

Objectives: To perform preliminary studies on an AY system as a means of controlling established perennial weeds in conventional and organic raspberry culture.

Procedures:

This would be the first year of a three-year trial (2006-2008). Two sites are suggested for this trial: one in organic production and one in conventional production, preferably near Mount Vernon and Lynden. Established raspberry rows should be at least moderately infested with several perennial weed species and the grower-cooperator must be willing to donate two adjacent raspberry rows to this trial for the three years and a third adjacent row for two years. During Year #1, Row A will be cleared of primocanes and perennial weed growth using several herbicide treatments and berries will be harvested from existing floricanes. Row B will be maintained in standard EY production (check plots). During Year #2, Row A will be allowed to grow primocanes (off-year, no harvest), Row B will maintained in standard EY production (check plots), and Row C will be cleared of primocanes and perennial weed growth using the same herbicide treatments tested on Row A in Year #1 and berries will be harvested from existing floricanes. During Year #3, Row A will cycle into its bearing year, Row C will cycle into its primocane growth year, and Row B will be maintained in standard EY production (check plots).

Perennial weed cover will be noted by species at the start of these trials. Contact herbicides to be tested in the bearing year of the AY system include Gramoxone (paraquat), Goal (oxyfluorfen), and Finale (glufosinate) in the conventional trial (Table 1), and 20% vinegar, Matran 2 (clove oil), and Organic Interceptor (pine oil) in the organic trial (Table 2). Applications will be made as necessary to control all growth under the floricanes. In the non-bearing year, Solicam (norflurazon), Karmex (diuron), or Princep (simazine) will be used in late-winter to provide for general weed control in the conventional trial, while 20% vinegar, Matran 2, and Organic Interceptor may be used for weed control in mid- to late-summer after the bases of the primocanes have hardened. Conventional check plots will be treated with a light rate of Casoron (dichlobenil) during dormancy followed by Aim (carfentrazone) in the spring (residual + cane burning), Casoron during dormancy alone (residual with no cane burning), or Aim in the spring alone (cane burning with no residual). Organic check plots will be maintained using whatever program is practiced by the grower-cooperator.

During the bearing year, fruit will be collected periodically from grower-cooperator machines used to harvest the rows and weighed. Fruit will also be sampled to determine berry size. Weed cover by species will be visually estimated at four times each year. Treatments and statistical replication will be nested within each row. At thirty feet per plot, three plots per replicate, and four replicates, each row should be 360 feet long.

Anticipated Benefits and Information Transfer:

These studies will improve perennial weed control practices in raspberries by adding to the knowledge of growers when they make decisions regarding herbicide selection and application. Data from this experiment may also provide good information on the practicality of implementing an AY system in raspberry. These data will be disseminated through extension bulletins and during grower meetings sponsored by extension faculty and the agricultural industry.

Table 1. Conventional system trial (cooperator near Lynden or Mount Vernon)

Row A (AY)		
Year #1, bearing year		
	Treatment 1	Gramoxone as necessary to control under-canopy growth
	Treatment 2	Goal as necessary to control under-canopy growth
	Treatment 3	Finale as necessary to control under-canopy growth
Year #2, off-year		
	Treatment 1	Solicam in late winter; possibly Gramoxone after primocane bases hardened
	Treatment 2	Karmex in late winter; possibly Goal after primocane bases hardened
	Treatment 3	Princep in late winter; possibly Finale after primocane bases hardened
Year #3, bearing year		
	Treatment 1	Gramoxone as necessary to control under-canopy growth
	Treatment 2	Goal as necessary to control under-canopy growth
	Treatment 3	Finale as necessary to control under-canopy growth
Row B (EY check plots)		
Year #1, 2, and 3		
	Treatment 1	Casoron at dormancy, Aim in early spring
	Treatment 2	Casoron at dormancy
	Treatment 3	Aim in early spring
Row C (AY)		
Year #2, bearing year		
	Treatment 1	Gramoxone as necessary to control under-canopy growth
	Treatment 2	Goal as necessary to control under-canopy growth
	Treatment 3	Finale as necessary to control under-canopy growth
Year #3, off-year		
	Treatment 1	Solicam in late winter; possibly Gramoxone after primocane bases hardened
	Treatment 2	Karmex in late winter; possibly Goal after primocane bases hardened
	Treatment 3	Princep in late winter; possibly Finale after primocane bases hardened

Table 2. Organic system trial (cooperator near Lynden or Mount Vernon)

Row A (AY)		
Year #1, bearing year		
	Treatment 1	20% vinegar as necessary to control under-canopy growth
	Treatment 2	Matran 2 as necessary to control under-canopy growth
	Treatment 3	Organic Interceptor as necessary to control under-canopy growth
Year #2, off-year		
	Treatment 1	20% vinegar (if possible after primocane bases hardened)
	Treatment 2	Matran 2 (if possible after primocane bases hardened)
	Treatment 3	Organic Interceptor (if possible after primocane bases hardened)
Year #3, bearing year		
	Treatment 1	20% vinegar as necessary to control under-canopy growth
	Treatment 2	Matran 2 as necessary to control under-canopy growth
	Treatment 3	Organic Interceptor as necessary to control under-canopy growth
Row B (EY check plots)		
Year #1, 2, and 3	As per grower-cooperator program	
Row C (AY)		
Year #2, bearing year		
	Treatment 1	20% vinegar as necessary to control under-canopy growth
	Treatment 2	Matran 2 as necessary to control under-canopy growth
	Treatment 3	Organic Interceptor as necessary to control under-canopy growth
Year #3, off-year		
	Treatment 1	20% vinegar (if possible after primocane bases hardened)
	Treatment 2	Matran 2 (if possible after primocane bases hardened)
	Treatment 3	Organic Interceptor (if possible after primocane bases hardened)

Budget:

Amount allocated to PI by Red Raspberry Commission for FY 2005-06: $ 7,000

	Requested 2006-07
Salaries	
A/P technician (Carl Libbey)	$ 3,000
Time-slip	2,000
Operations (goods & services)	800
Travel	
Projected needs[a]	500
Meetings	0
Other	0
Equipment	0
Employee Benefits	
A/P technician (37.5%)	1,125
Time slip (11%)	220
Total Request	$ 7,645

[a]Travel will be used for plot work at off-station sites near Lynden and Mount Vernon, WA.

Other Support of Project:

Herbicides are typically provided by herbicide manufacturers.

Project No: new

Title: Effects of drip tape placement on spread of raspberry root rot caused by *Phytophthora fragariae* var. *rubi*

Year Initiated 2006 Current Year 2006-2007 Terminating Year 2008

Personnel:

Thomas Walters, WSU Dept. Horticulture and Landscape Architecture, Mount Vernon
Gary Grove, WSU Dept Plant Pathology, Prosser

Cooperators:

Patrick P. Moore, WSU Dept Horticulture and Landscape Architecture, Vancouver

Justification and Background:

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

Raspberry growers need to irrigate to maximize yields and quality. Although rainfall is abundant in western Washington State, it is usually lacking in the summer, when the plants' water requirements are the greatest. Shallow-rooted berry plants are unable to reach enough water deep in the soil, and they become water-stressed, causing yield reductions in the current year and in the following year.

However, irrigation practices can worsen raspberry root rot problems by generating soil conditions favorable to *Phytophthora* root rot during the summer months. Irrigation practices have large effects on *Phytophthora* disease development in other crops. Drip emitters on the surface and in the row enhanced development of *Phytophthora* root rot of pepper (Café-Filho and Duniway, 1996). Subsurface emitters gave better disease control without reducing yields in noninfested plots. The frequency of irrigation has also been shown to affect *Phytophthora* diseases of squash (Café-Filho et al., 1995) and tomato (Ristaino et al., 1988): more frequent irrigations favor more severe disease development. The development and dispersal of *Phytophthora* spores is favored by cycles of soil moisture, as would likely be caused by common irrigation practices (Ristaino and Johnston, 1999). When irrigation was managed so that soil moisture in the root zone of peppers was neither excessively high nor excessively cyclical, *Phytophthora* blight of peppers was successfully controlled. In red raspberry, cultural practices that affect soil moisture, such as hilling and mulching, also affected Phytophthora root rot development (Wilcox et al., 1999).

Root rot development in susceptible pepper varieties was sensitive to irrigation scheduling, but resistant varieties tolerated even very moist conditions (Café-Filho and Duniway, 1995). Early season *P. capcisi* inoculum in pepper fields was highest near the drip line (Ristaino et al., 1992). Inoculum buildup might be avoided if irrigation was alternated between two drip tapes. Resistant varieties are probably the most promising long-term solution to Phytophthora root rot diseases of strawberry (Martin and Bull, 2002) and raspberry (Duncan and Cooke, 2002). The new WSU raspberry varieties 'Cascade Bounty' and 'Cascade Delight' appear to have a high degree of root rot resistance (Moore, 2004), but their response to irrigation treatments is unknown.

Objectives:

Year 1: Determine the effects of irrigation water timing and placement on the incidence and spread of Raspberry root rot, caused by *Phytophthora fragariae* var. *rubi*.

Year 2: Confirm the results of year 1, and establish the effect of deep vs. shallow irrigation cycling.

Year 3: Refine the effect of deep vs. shallow irrigation cycling on spread of raspberry root rot, and publish an extension bulletin summarizing best irrigation practices for raspberry.

Procedures:

New raspberry plantings will be established at the Mount Vernon (moderate root rot pressure) and Puyallup (high root rot pressure) research stations. If conditions at Puyallup are not suitable, trials may be established in commercial fields. Irrigation treatments will include: drip tape 4-6" below the surface, 18" above the surface directly above the crowns, and two tapes on the surface 6" offset from the crowns. Irrigation will maintain soil moisture at near soil capacity at 24" soil depth and to approximately 50% of soil capacity at 12". The same volume of water will be administered to all of these treatments. Soil moisture will be monitored with Watermark sensors at 12" and 24" in two replications of each treatment. The plots at Mount Vernon will be inoculated (either zoospores produced from culture or infected planting stock), and disease progress will be monitored through the 2006 and 2007 seasons. Several plants will be removed from each plot in the winter of 2006 to evaluate root biomass, disease incidence and severity. A sampling of diseased plants will be sent to the OSU plant disease clinic for positive identification of *P. fragariae* via PCR. Primocane numbers, diameter and length will be recorded, as will fruit yield. These plots will be 10 plants (35 feet) feet long. There are 3 treatments x 2 varieties ('Meeker' and 'Cascade Bounty') and 5 replicates, for a total of 30 plots, or approximately 0.62 A. at each location. Plots will be established in a randomized complete block design; data will be analyzed with a two-way (irrigation treatment and variety) ANOVA.

In parallel pot studies at Mount Vernon, overhead and subsurface irrigation treatments will be administered to infected planting stock in the greenhouse. Pots will be brought to the capacity of the potting mix every third day. Half of the plants will be sacrificed at the end of the growing season, and primocane and root biomass will be evaluated. Disease incidence and development will be evaluated.

Additional studies (planned for 2007 and 2008) will evaluate the effect of irrigation cycling depth on disease development and spread. In these studies, irrigation cycles will be deep (initiated at -50 mPa water potential at a 12" depth), moderate (initiated at -30mPa water potential at a 12" depth) or shallow (initiated at -10 mPa water potential at 12" depth) applied either applied via an automated irrigation scheduler.

References:

Café-Filho, A.C.and J.M. Duniway. 1995. Effect of furrow irrigation schedules and host genotype on Phytophthora root rot of pepper. Plant Disease. 79: 39-43.

Café-Filho, A.C.and J.M. Duniway. 1996. Effect of location of drip irrigation emitters and position of Phytophthora capsici infections in roots on Phytophthora root rot of pepper. Phytopathology 86: 1364-1369.

Café-Filho, A.C., J.M. Duniway, and R.M. Davis. 1995. Effects of the frequency of furrow irrigation on root and fruit rots of squash caused by *Phytophthora capsici*. Plant Disease. 79: 44-48.

Duncan, J.M.and L.E.M. Cooke. 2002. Work on raspberry root rot at the Scottish Crop Research Institute. Acta Horticulturae. 585: 271-276.

Martin, F.N.and C.T. Bull. 2002. Biological control of root pathogens of strawberry Phytopathology 92: 1356-1362.

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

Ristaino, J.B., J.M. Duniway, and J.J. Marois. 1988. Influence of frequency and duration of furrow irrigation on the development of Phytophthora root rot and yield in processing tomatoes. Phytopathology 78: 1701-1706.

Ristaino, J.B., M.J. Hord, and M.L. Gumpertz. 1992. Population densities pf Phytophthora capsici in field soils in relation to drip irrigation, reinfall and disease incidence. Plant Disease. 76: 1017-1024.

Ristaino, J.B.and S.A. Johnston. 1999. Ecologically Based Approaches to management of Phytophthora blight on bell pepper. Plant Disease. 83: 1080-1089.

Wilcox, W.F., M.P. Pritts, and M.J. Kelly. 1999. Integrated control of Phytophthora root rot of red raspberry. Plant Disease. 83: 1149-1154.

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

Anticipated Benefits and Information Transfer:

Results will be presented to Washington raspberry growers at field days, grower meetings and at commission meetings. The results will also be incorporated into an extension bulletin on irrigation practices for berry crops in Washington. This knowledge will help growers to design raspberry drip irrigation systems significantly reduce Phytophthora root rot pressures through attention to their irrigation practices. Better yields and less disease will help berry production remain an economically viable activity in the state, and will contribute to rural economic health.

Budget:

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

	2006	2007	2008
Salaries[1/]	$2,438	$2,535	$2,636
Time-Slip	$500	$500	$500
Operations (goods & services)	$1,000	$250	$250
Travel[2/]	$500	$500	$500
Projected Needs			
Meetings			
Other		$250	$250
Equipment[3/]	$1,500	$250	$250
Employee Benefits-RA[4/]	$1,048	$1,090	$1,134
Employee Benefits-Time-slip	$55	$55	$55
Total	**$7,041**	**$5,430**	**$5,575**

[1] Research Associate, 0.075 FTE.

[2] To and from remote plots in Puyallup or in growers' fields; also two visits from G. Grove to Mt Vernon/Lynden and Puyallup/Vancouver.

[3] Posts, wire, Watermark soil moisture sensors and dataloggers, drip tape, filters, automated irrigation system.

[4/] RA benefits estimated 43%; time-slip 11%.

Other support of project:
Approximately 0.75 FTE of a Research Associate is provided to the small fruit horticulture program by the Agricultural Research Center in the first two years.

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

A proposal for matching funds will be made to the Washington State Pesticide Commission. **The budget above is my request to the Raspberry Commission; completion of all the work described will require matching funds from the Washington State Pesticide Commission.**
Sakuma Bros Farms, Inc. will provide plants.

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

Current & Pending Support

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

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
	Current:				
Walters	Pending: Washington State Pesticide Commission	$7041	2006	0.2	**Effects of drip tape placement on spread of raspberry root rot caused by *Phytophthora fragariae* var. *rubi***

Project No: new

Title: Irrigation deficits at critical raspberry developmental stages and cover crops to reduce nitrate leaching potential.

Year Initiated 2006 **Current Year** 2006-2007 **Terminating Year** 2008

Personnel:

Thomas Walters, WSU Dept. Horticulture and Landscape Architecture

Justification and Background:

Water deficit impacts. Raspberry growers need to irrigate to maximize yields and quality. Although rainfall is abundant in western Washington State, it is usually lacking in the summer, when the plants' water requirements are the greatest. Shallow-rooted berry plants are unable to reach enough water deep in the soil, and they become water-stressed, causing yield reductions in the current year and in the following year.

Under-irrigated berry crops have poor vegetative growth, reduced fruit yield and smaller fruit (Kirnak et al., 2003 ; MacKerron, 1982). Over-irrigation brings risks of poor plant performance, soil-borne disease and nitrate leaching into groundwater. An interested person can generally predict how much water is enough (by using evapotranspiration models), and monitor if enough water is getting to the plants (by monitoring soil moisture and plant water status), but we don't really know if there are critical stages at which adequate water is essential. Are there critical stages at which we must meet the crop's water needs? Are there other times at which subjecting plants to water stress is not harmful, or is actually beneficial?

Growers sometimes estimate the need for irrigation by sampling the soil several inches below the surface. However, deeper sampling is required. Raspberry roots extend over 3 feet deep, and moisture near the soil surface does not guarantee adequate moisture deeper in the soil. Crop irrigation needs are generally predicted on the basis of evapotranspiration (ET); the evapotranspiration rates of individual crops (ET_c) are defined in relation to the evapotranspiration of a reference crop via a crop coefficient. Crop coefficients vary with the plant developmental stage, and fruit crop coefficients are generally highest during fruit expansion and ripening. Crop coefficients for raspberries were developed by the US bureau of Reclamation in 1975, and are available through the Agri-Met Agricultural Weather Network (http://www.usbr.gov/pn/agrimet). However, berry production practices and varieties have changed a great deal since that time, and the coefficients are likely outdated. Recently released raspberry varieties (such as 'Cascade Bounty') have high fruit yields without a correspondingly larger canopy. Older canopy coverage-based models may not be appropriate for these varieties.

A clear understanding of raspberry water requirements coupled with appropriate practices to meet these requirements would allow improve berry yields, prevent the spread of soil-borne disease with reduced chemical usage, avoid groundwater contamination, and use water resources wisely. The impact of these measures would be felt throughout berry-growing regions.

Minimizing nitrate leaching in raspberry production. Berries in Western Washington are generally grown in soils with extremely high water tables; in some cases, these soils are quite sandy, and are therefore prone to leaching. Nitrate contamination of groundwater wells has been repeatedly documented in areas of berry production in NW Washington (Mitchell et al., 2005). These reports point to human causes of contamination, including dairy and poultry operations, and possibly berry producers' use of dairy and poultry manure, as well as inorganic nitrogen fertilizers. In other crops, including strawberry, excessive irrigation and fertilization exacerbate nitrate leaching into the environment (Guimera et al., 1995)

Recommended practices to avoid nitrate contamination of groundwater include: use of deep-rooted crops to scavenge residual nitrogen, evaluation of soil and irrigation water nitrate levels to appropriately adjust recommended fertilizer levels, evaluation of leaf tissue to determine whether current fertilizer programs are appropriate and consider conservation tillage practices (British Colombia Ministry of Agriculture, 2005; Canessa and Hermanson, 1994). In the case of raspberries, deep-rooted nitrogen scavengers may be feasible in the current production system, as long as these do not interfere with machinery needed to manage the crop. Groundcover management significantly affects nitrate leaching in apple orchards (Merwin et al., 1996). Careful attention to the form, amount and timing of N application may also reduce leaching. Blackberries took up soil N from late April through July (Mohadjer, 1999). Split applications of N are recommended for raspberries, and up to three N applications are suggested for on very gravely soils (British Colombia Ministry of Agriculture, 2005; Pritts and Handley, 1994), but data is lacking on the actual effect of this practice on nitrate leaching. Post-season foliar N testing is considered to be an effective means of evaluating whether appropriate levels of N have been made available to the raspberry plant in the previous growing season (British Colombia Ministry of Agriculture, 2005), but the testing is not widely employed. A post-harvest soil nitrate test can assess the risk of nitrate leaching in the following winter, and can also be a guide to N requirements for the next year's crop, if the N is captured with a cover crop (British Colombia Ministry of Agriculture, 2005).

Objectives:

Year 1: Evaluate irrigation deficit effects on current year's growth and yield. Evaluate cover crop growth and initial Nitrate uptake effects

Year 2: Evaluate irrigation deficit effects on following year's yield, and repeat treatments of year 1. Evaluate cover crop N uptake effects into following growing year, and repeat treatments of year 1.

Year 3: Complete evaluations of year 2 treatments, publish berry irrigation guide.

Procedures:

Water deficit impacts at critical growth stages. In raspberry and blueberry, we will use existing plantings at the Vancouver, WA research and extension center, or at an alternate site in a grower's field. Established raspberry plantings will be drip-irrigated 2 times per week to 100% ETc levels from April 15-Sept 15. Reference ET will be taken from the nearest Agri-Met station (Forest Grove, OR), and the Agri-Met crop coefficients will be used to calculate ET_c. Soil moisture will be monitored with watermark sensors and automated dataloggers in two replicates of the fully irrigated plots. Irrigation practices will be adjusted as needed to maintain fully irrigated plots at close to field capacity at 24" soil depth and at approximately 50% of field capacity at 12" depth. Individual plots will be subjected to moisture stress (approximately 50% ET) during bloom, harvest, and post-harvest periods. Plant water potential, vegetative growth, yield, initiation of floral buds for the following season, root rot development, and yield in the following season will be evaluated. Winter-hardiness will be evaluated if conditions permit (if winter injury is present in the plots). Individual plots will contain 10 plants and be approximately 35 feet in length. Data will be taken from the middle 8 plants of each plot. Including the fully irrigated control, there will be 4 treatments: 1) fully irrigated control 2) 50% ET Bloom to harvest, 3) 50% ET Harvest, 4) 50% ET post-harvest. These will be laid out in a randomized complete block design, with 5 replicates and a total of 20 plots. There will be 1400 row-feet in the trial; perhaps up to 1800 row-feet with boarder rows. At 10' spacing, this is approximately 0.41 A. Treatments will be made through the 2006 and 2007 growing seasons; evaluations will be made into the 08 growing season, if possible.

Minimize Nitrate leaching. Raspberry cv. 'Meeker' plants being established on a silt loam soil at Mount Vernon NWREC will receive 1) 60 lb N per acre in a single application in April, 2) the same amount of N split between two applications in April and May, 3) 120 lb/A N split between 2 applications and 4) 60 lb/A N as dairy manure applied early in April. Plant vegetative growth and foliar N will be evaluated throughout the season. Foliar N and soil nitrate will be evaluated on or about August 1 to determine whether these treatments provide appropriate amounts of N to the plants, and the extent to which they predispose soil to nitrate leaching. It is anticipated that the 120 lb N applied to treatment 3 will result in significant residual nitrate in the soil. A barley or oat cover crop will be established in half of the plots to establish the cover crop's ability to recover excess nitrates from the soil. The biomass and %N of the cover crop will be evaluated mid-October. Soil nitrate in cover-cropped and bare plots will be evaluated mid-October 2006 and mid-March 2007. Effects of N treatments will be applied in randomized complete blocks and evaluated as a one-way ANOVA; cover crop treatments will be applied as a split-plot design within the N treatments and analyzed accordingly.

Within established raspberry fields, cover crops of barley, oats and crucifers will be established immediately after post-harvest operations (ca August 15). Soil nitrate levels in cover-cropped and bare areas will be evaluated the following spring (ca April 1) to evaluate the capacity of the cover crops to hold Nitrogen over the winter.

References:

British Colombia Ministry of Agriculture, F.a.F. 2005. Berry production guide for commercial growers 2005-2006 edition. Lower Mainland Horticulture Improvement Association, Abbotsford, BC.

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Guimera, J., O. Marfa, L. Candela, and L. Serrano. 1995. Nitrate leaching and strawberry production under drip irrigation management. Agriculture, ecosystems and Environment. 56: 121-135.

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Mitchell, R.J., R.S. Babcock, H. Hirsch, L. McKee, R.A. Matthews, and J. Vandersypen. 2005. Water Quality: Abbotsford-Sumas Final Report.

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Anticipated Benefits and Information Transfer:

Results will be presented to Washington raspberry growers at field days, grower meetings and at commission meetings. The results will also be incorporated into an extension bulletin on irrigation practices for berry crops in Washington. This knowledge will help growers more closely understand raspberry water requirements, especially at critical times in the plant's development. Results of the cover crop studies will also be shared with the Mitchell lab at Western Washington University to help them make their nitrate leaching models more accurately reflect field realities.

Budget:

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

	2006	2007	2008
Salaries[1/]	$3,250	$3,380	$3,515
Labor costs at Vancouver(time-slip)	$1,000	$1,000	$500
Operations (goods & services)[2/]	$2,000	$2,000	$500
Travel[3/]	$500	$500	$500
Projected Needs			
Meetings			
Other		$500	$500
Equipment[4/]	$2,000	$500	$500
Employee Benefits-RA[5/]	$1,398	$1,453	$1,511
Employee Benefits-Time-slip[5/]	$110	$110	$55
Total	**$10,258**	**$9,443**	**$7,581**

[1] Research Associate, 0.10 FTE.
[2] Plot maintenance at Vancouver.
[3] To and from plots in Vancouver or in growers' fields.
[4] Watermark soil moisture sensors and dataloggers, drip tape, filters, automated irrigation system.
[5] RA benefits estimated 43%; time-slip 11%.

Other support of project*:
Approximately 0.75 FTE of a Research Associate is provided to the small fruit horticulture program by the Agricultural Research Center in the first two years.

A substantial amount of equipment costs for this project (for example, mechanical harvester, vehicle, balances) are covered by the Agricultural Research Center of Washington State University. WSU is also providing facilities and locations at Vancouver and Mount Vernon.

Additional funds are requested from NARF to help in establishing new raspberry plantings at Mount Vernon.

* Budget data provided in "Other support of project" is for informational purposes only, for the 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

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

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
	Current:				
Walters	Pending: NARF	$7,718	2006	0.2	**Evaluation of Small Fruits at WSU Mt. Vernon**

EXECUTIVE SUMMARY SHEET

PROJECT TITLE: Field evaluation of raspberry irrigation systems

INVESTIGATOR: T.W. Walters, Assistant Horticulturist, WSU-Mt Vernon NWREC, in cooperation with David Bryla, USDA-ARS Horticultural Crops Research Unit, Corvallis OR and Wei Yang, Oregon State University

PROJECT NUMBER: new

PROJECT DURATION: 1 year

CALENDAR YEAR: 2006-2007

PROPOSED BUDGET: $16,314

OTHER SUPPORT: (Pending) WA Blueberry Commission ($8,898), WA Strawberry Commission ($4,449), Northwest Center for Small Fruit Research ($33,821).

IDENTIFICATION OF PROBLEM OR NEED: Raspberry plants are shallow-rooted and susceptible to both drought and over-watering. Irrigation needs to be uniform and matched with the crop's water use to optimize plant performance, and to avoid nutrient leaching into groundwater. Trained irrigation systems evaluators will help growers identify and resolve sources of non-uniformity in their irrigation systems, and will help growers effectively match irrigation with plant water use.

BENEFITS: Raspberry plantings will be more productive by improving the uniformity of irrigation application and by more closely matching irrigation with the crop's needs. The risk of nitrate leaching will be reduced by avoiding over-irrigation.

ECONOMIC JUSTIFICATION: Raspberry production is extremely cost-competitive and the profit margin frequently slim. Better use of water, a relatively inexpensive resource, will help to improve the overall productivity and profit.

EVALUATION AND ACCOUNTABILITY: The scientist (Walters) is responsible for conducting this project and reporting it to the raspberry industry and the scientific community. An extension publication will be developed to enable growers to carry out their own evaluations in the future.

Project No:

Title: Field evaluation of raspberry irrigation systems

Year Initiated N/A **Current Year 2006-2007** **Terminating Year 2006-2007**

Personnel: T.W. Walters, Assistant Horticulturist, WSU-Mt Vernon NWREC
Cooperators:
David Bryla, USDA-ARS Horticultural Crops Research Unit, Corvallis OR
Wei Yang, Oregon State University North Willamette Research and Extension Center, Aurora OR

Justification:
Since rainfall is not sufficient in the late spring and summer months when raspberry water needs are the greatest, irrigation is essential for optimum productivity. The general rule of thumb in the Pacific Northwest is to irrigate raspberries with approximately 1-1.75 inches of water per week during times of peak demand (Hess et al., 1997). However, system limitations and harvest restrictions sometimes hinder adequate irrigation. Inadequate irrigation, especially during later stages of fruit development, reduces fruit size and decreases yield and berry quality. Over-irrigation can exacerbate soil-borne disease problems.

To apply the right amount of water to raspberry crops, growers need to know the efficiency of their irrigation systems. Irrigation efficiency is defined as the ratio of the irrigation water beneficially used by the crop to the water delivered to the crop. Irrigation efficiency is reduced when water evaporates from the soil surface, percolates below the root zone, runs off the field or is carried off by the wind (Jensen et al, 1990). Drip irrigation systems typically have very high irrigation efficiencies when properly maintained and used, and also reduce plant stress by allowing more frequent irrigations. Sprinkler systems, including solid set and big guns are typically less efficient, due to soil evaporation after irrigation and water loss between rows.

Irrigation efficiency in either drip or sprinkler systems is reduced by flow variation, generally due to poor emitter design or placement, plugging, leaks, pressure differences within the field or low rates of soil infiltration (Burt et al., 1995).

Funding is requested for systematic evaluations of individual growers' irrigation systems. These evaluations will help growers deliver the right amount of water to raspberry fields with their own irrigation systems. To do this, evaluators will help growers identify and resolve sources of flow variation, determine irrigation efficiency, and determine the crop's needs.

This project will be carried out in close cooperation with David Bryla (USDA-ARS) and Wei Yang (OSU), who have proposed a similar project to the NW Center for Small Fruits Research grants program. Funding is also requested from the Washington Blueberry and Strawberry commissions.

Objectives:

1. Evaluate uniformity, efficiency and capacity of raspberry irrigation systems in Washington. Provide recommendations for system improvements as needed.
2. Monitor plant water status and identify fields exposed to water stress due to inadequate irrigation.
3. Update guidelines for system maintenance and irrigation scheduling

Procedures:

Evaluations will be on a first-come, first-served basis. The program will be publicized through meetings and newsletters to make it available to the largest possible number of berry growers in the state. Raspberry growers throughout western Washington will be targeted.

Irrigation systems will be evaluated according to methods developed in the Irrigated System Evaluation Manual (Burt et al., 1992). Uniformity will be evaluated by measuring delivery at multiple locations and dividing the lowest quartile by average delivery. Water inflow, emitter flow rate and system pressure will also be monitored to help identify sources of non-uniformity.

Adequacy of timing and amount of irrigation will be evaluated as the capacity of the applied water to return soil water content in the root zone to near field capacity. Changes in soil water content during irrigation will be measured with time-domain reflectometry or Watermark probes.

Pump flow rates will be monitored during irrigation when possible to determine system pumping capacity. Filtration will be assessed by examining system components for sediment and organic matter buildup.

Leaf water potential will be used to evaluate plant water status, and to identify areas where irrigation is insufficient. Plant water potential, irrigation, irrigation efficiency and yield data will be compiled to establish standards and relationships among these factors.

Anticipated Benefits and Information Transfer:

Growers participating in the study will receive detailed evaluations of their irrigation systems, enabling them to:

- improve the efficiency of their irrigation systems
- know the capacity of their systems
- effectively schedule irrigations to best meet the crop's needs, taking their own soil types and irrigation systems into consideration.

An extension publication will be developed to enable growers to carry out their own evaluations in the future.

Literature Cited:

Burt C.M., Walker R.E., Styles S.W. 1992. Irrigation System Evaluation manual. Irrigation Research and Training Center. California Polytechnic State University, San Luis Obispo, CA

Burt C.M., Clemmens A.J., Solomon K.H. 1995. Identification and quantification of efficiency and uniformity components. In: Proceedings of the ASCE Water Conference, pp. 1526-1530. San Antonio, Texas.

Jensen M.E., Rangeley W. R., Dielman P.J., 1990. Irrigation trends in world Agriculture. In: Irrigation of Agricultural Crops (B.A. Stewart and D.R. Nielson eds), pp. 31-67. Agron. Monogr. No. 30. ASA-CSSA-SSA Publ., Madison, WI.

Budget request for FY 2006-2007:

Salaries[1/]	$ 8,903
Time-Slip	
Operations (goods & services)	
Travel[2/]	$ 825
Projected Needs	
Meetings	
Other[3/]	$ 2,401
Equipment	
Employee Benefits[4/]	$ 4,185
Total Requested[5/]	$16,314

[1/]Temporary Research Associate, 0.583 FTE (full-time April-October).

[2/]Travel budget is for Research Associate to attend irrigation evaluation training at Cal Poly.

[3/]vehicle mileage May-Sept

[4/]47% of salary

[5/]Total represents 55% of the total costs for an irrigation systems evaluator in Washington.

Other support of project*:

Funding has also been requested from the Northwest Center for Small Fruits Research and the Washington Blueberry and Strawberry Commissions. If all of these proposals are successful, there will be two technicians evaluating irrigation systems in 2006. Funding from the Washington Raspberry, Blueberry and Red Raspberry commissions together will support a temporary (April through October 2006) Research Associate based in Washington, and funding from the Northwest Center will support a technician in Oregon.

- Budget data provided in "Other support of project" is for informational purposes only, for the 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

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3. Provide analogous information for all proposed research which is being considered by, or which will be submitted in the near future to, other possible sponsors.

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
	Current:				
	Pending:				
Walters, Bryla, Yang	Washington Blueberry Commission	$8898	FY 2006-2007	0.2	Field evaluation of blueberry irrigation systems
Walters, Bryla, Yang	Washington Strawberry Commission	$4449	FY 2006-2007	0.2	Field evaluation of strawberry irrigation systems
Bryla, Walters, Yang	Northwest Center for Small Fruit Research	$33821	FY 2006-2007	0.5	Field evaluation of irrigation systems used for berry crop production in the Pacific Northwest