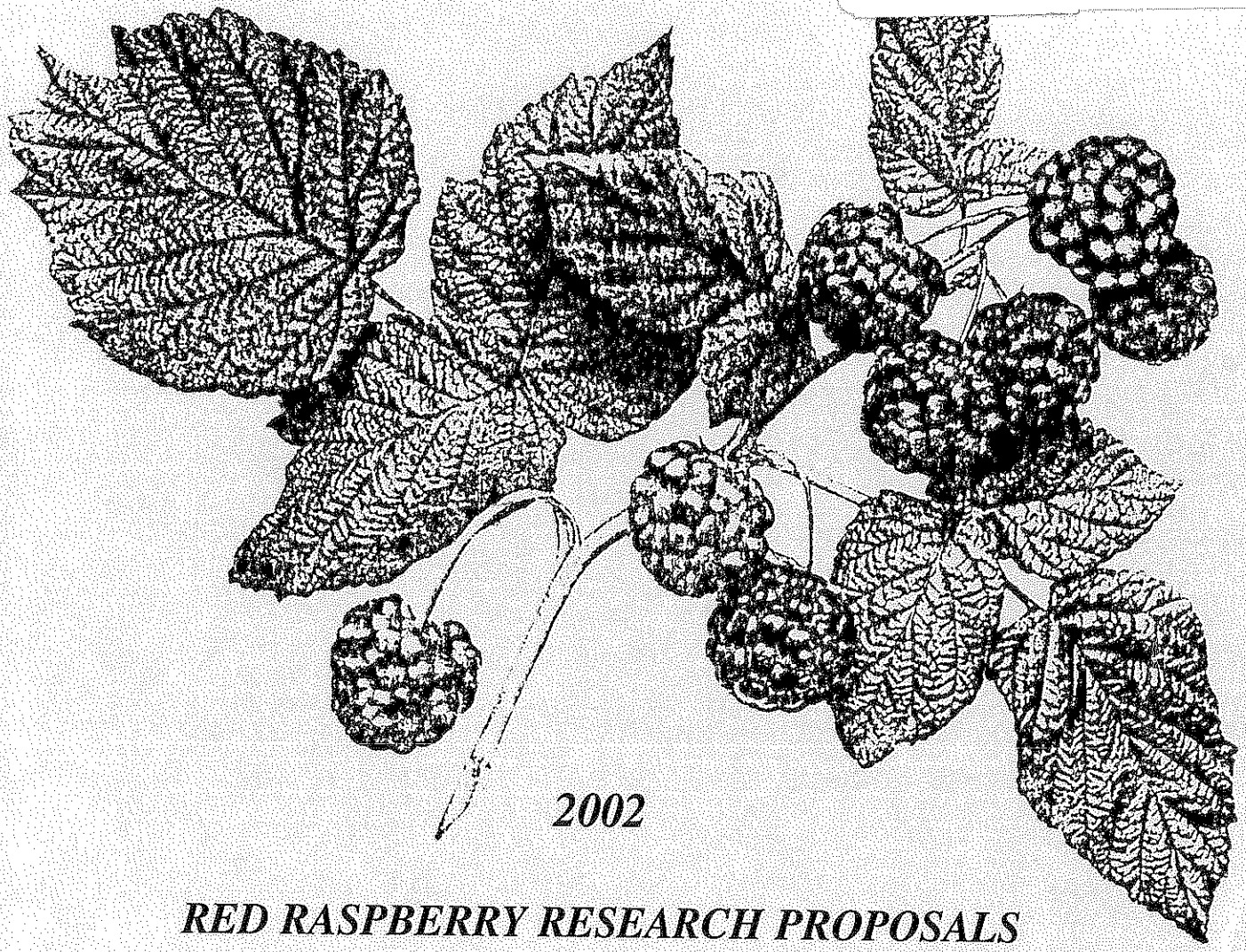

2002

RED RASPBERRY RESEARCH PROPOSALS

2001 PROGRESS REPORTS

to the

WASHINGTON STATE RED RASPBERRY COMMISSION

and

NORTHWEST RED RASPBERRY GROWERS ASSOCIATION

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2001-2002

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A:RaspComm.02/cp4/cm 11/01

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Summary
Budget Requests

On-Going Projects

Project No.	Short Title	Lead Scientist	Amount Requested
13C-3755-5641	Raspberry Breeding	Moore	$ 20,870
13C-3755-7641	Advanced Testing/Vancouver	Moore	1,000
13C-3755-8641	Advanced Testing/Mt. Vernon	Moore	500
	Bushy Dwarf Resistance	Martin	5,000
	Cultivar Development for PNW	Kempler	8,000
13C-3761-5253	Phytophthora root rot Survey	Bristow	-0-
13C-3761-4251	Rates/Sources of Gypsum	Bristow	-0-
13C-3419-3297	Caneburning	Miller	7,300
3555-3375	Root Rot Control	Miles	5,000

New Projects

Short Title	Lead Scientist	Amount Requested
Gray mold fruit rot	Bristow	$ 8,970
Insect & Mite Control	Tanigoshi	4,640

A:Raspbk.02/cp4/cm
11/01

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: 2001

Accomplishments:
In 2001, 47 crosses were made for cultivar development and 31 crosses involved interspecific hybrids as parents. Over 6,000 seedlings were planted at Puyallup from 2000 crosses. Selections will be made among these seedlings in 2003 and 2004. A new replicated planting was established of 273 plots with 86 clones (62 WSU selections and 15 BC selections) on raised beds treated with gypsum and Ridomil. Forty-nine selections were made among the seedlings that were planted in 1998 and 1999.

The 1998 replicated planting was harvested for the first time in 2001 (Table 1). In 2000, this planting was not harvested because of deer browsing. A deer fence was constructed and these plots were harvested in 2001. Because of funding limitations, only 66 of the 150 plots were harvested, representing 23 of the 50 clones in the planting. Seven selections had yields over 10 t/a. Of these seven selections, only WSU 1201 had a raspberry bushy dwarf virus (RBDV) resistant parent. Many of these selections had average fruit weight between 3.0 and 4.2 g and reasonable fruit firmness. These characteristics may be more adapted to machine harvesting than larger fruit. The highest yielding cultivars were Tulameen (9.9 t/a) and Meeker (8.5 t/a).

WSU 1090 will be recommended for release this winter. It has consistently been very large fruited (averaging 5.0 g in four plantings compared to 4.3 g for Tulameen) and firm (averaging 203 g compared to Tulameen with 174 g). WSU 1090 may have some field resistance to root rot. At WSU Mt. Vernon the planting established in 1998 had some areas with severe root rot. WSU 1090 was undamaged, while Tulameen, Willamette, Comox, Qualicum and Meeker were killed or severely damaged in adjacent plots. Data to support a patent application was collected this summer.

WSU 1226 is a selection that produces very, very large, very, very firm fruit with a very late season. Because very early fruit appeared to have some misshapen fruit and to be difficult to pick, harvest data was not collected for this selection in 2001. Later in the season, the fruit had a better appearance. A small sample of large fruit harvested August 7 had fruit of 9.8-13.9 g and firmness over 350 g.

Publications/Presentations:
Finn, C. E., F. Lawrence, G. Langford, P.P. Moore, B. Yorgey and B. Strik. Lewis Raspberry. HortScience (In Press)

Finn, C., H. Swartz, P.P. Moore, J.R. Ballington, and C. Kempler. Use of 55 Rubus species in four North American Breeding Programs-Breeders Notes. Acta Hort. (in review)

Burrows, C and P.P. Moore. Genotype x Environment Effects on Raspberry Fruit Quality. Acta Hort. (in review)

Moore, P.P., C. Burrows, J. Fellman and D.S. Mattinson. Genotype x Environment Variation in Raspberry Fruit Aroma Volatiles. Acta Hort. (in review)

January, 2001. Strawberry and Raspberry fruit display. Northwest Food Processors, Portland, OR.

July 2001. Raspberry Field Day, Puyallup, WA.

July 2001. Small Fruit Open House, Mt. Vernon, WA

August 2001. Vancouver Field Day, Vancouver, WA

Table 1. 2001 harvest data of 1998 planted raspberries, Puyallup, WA

	Yield (t/a)	Fruit weight (g)	Fruit firmness (g)	Fruit rot (%)	Harvest season 5%	50%	95%	length (days)
WSU 1253	12.41 a	3.14 gh	188 c-f	0.6 de	7/5 e-h	7/18 fg	8/1 d	27 a-e
WSU 1129	12.31 ab	3.32 fg	132 j	2.1 b-d	7/8 d-f	7/21 c-e	8/6 bc	30 ab
WSU 1242	11.62 a-c	3.27 fg	200 b-e	0.9 c-e	7/12 ab	7/24 bc	8/7 bc	25 c-f
WSU 1201	11.47 a-c	4.07 b-d	182 e-g	1.6 b-e	7/8 c-e	7/22 b-d	8/7 ab	30 a
WSU 1220	11.29 a-d	4.19 bc	207 a-d	3.7 a	7/5 e-h	7/18 fg	8/2 d	27 a-d
WSU 1219	10.50 a-e	4.09 b-d	224 a	1.6 b-e	7/15 a	7/27 a	8/11 a	27 a-d
94530-1	10.37 a-e	5.34 a	216 ab	0.8 c-e	7/6 e-g	7/19 e-g	8/1 d	26 b-f
Tulameen	9.90 a-e	4.43 b	185 d-g	2.0 b-d	7/5 f-h	7/17 gh	8/3 cd	29 a-c
WSU 1250	9.78 a-e	3.30 fg	178 e-h	2.8 ab	7/2 ij	7/14 i	7/27 e	25 c-f
WSU 1240	9.66 a-e	3.98 b-e	225 a	2.4 a-c	7/5 f-h	7/19 e-g	8/1 d	27 a-e
WSU 1252	9.51 a-e	3.40 fg	180 e-g	1.0 c-e	7/12 ab	7/24 b	8/8 ab	27 a-e
WSU 1212	8.95 b-f	4.05 b-d	155 hi	2.2 a-d	7/7 e-g	7/17 gh	7/28 e	21 g
WSU 1234	8.82 c-g	3.65 d-f	200 b-e	0.6 de	7/11 bc	7/22 b-d	8/7 bc	27 a-e
WSU 1090	8.59 c-g	4.94 a	197 b-e	2.8 ab	7/10 b-d	7/21 d-f	8/2 d	22 fg
WSU 1221	8.58 c-g	3.30 fg	195 b-e	1.5 b-e	7/8 d-f	7/20 d-f	8/3 cd	26 b-f
Meeker	8.52 c-g	3.53 e-g	176 e-h	0.6 de	7/11 b	7/21 c-e	8/4 b-d	24 d-g
WSU 1181	8.26	3.05	171	1.4	7/4	7/17	7/29	25
WSU 1214	7.97 d-g	3.74 d-f	166 f-i	1.9 b-e	7/3 hi	7/15 hi	7/26 e	23 d-g
Willamette	7.81 e-g	3.27 fg	147 ij	2.1 b-d	6/27 k	7/8 k	7/20 f	23 d-g
WSU 1237	7.39 e-g	3.08 gh	164 g-i	0.4 e	7/11 b	7/20 d-f	8/1 d	21 g
WSU 1209	7.08	4.34	207	0.7	7/6	7/17	7/30	24
WSU 1239	6.08 fg	4.04 b-d	211 a-c	2.3 a-c	7/4 g-i	7/17 gh	8/2 d	29 a-c
Nootka	5.51 g	2.72 h	110 k	2.0 b-d	6/30 jk	7/11 j	7/26 e	26 b-f
Average	9.23	3.75	183	1.7	7/7	7/19	8/1	26

PROJECT: 13C-3755-5641
TITLE: Red Raspberry Breeding, Genetics and Clone Evaluation
YEAR INITIATED:1996
CURRENT YEAR:2002
TERMINATING YEAR:2003

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 entire 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.

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 which depends on continuity of effort.

Normally, 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. However, because of reduced funding avail, a maintenance budget and a full budget will be proposed.

Maintenance Effort

1. Plantings that are currently in the field (12 acres of seedlings, 2 acres of replicated yield plots and 1 acre of breeding plots) will be maintained. Plants in the greenhouse and screenhouses will be maintained.

2. Crosses will be made for summer fruiting cultivar development. Clones identified by ongoing disease and insect resistance, and fruit color studies will be used as parents. Other important traits included are ease of fruit removal, fruit firmness, fruit size, fruit color, harvest season, fruit rot resistance, and growth form. (Crosses made by Moore)

3. Seed from crosses made in 2001 will be stored until sufficient funding is obtained.

4. Selections will be made among the seedlings planted in 1999 and 2000. 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. (Selections made by Moore)

5. Seedlings selected in 2001 will be propagated for testing. Shoots of all selections will be collected and placed into tissue culture. (Propagation funded by NW Center for Small Fruit Research).

5. The replicated plantings established in 1998, 1999 and 2000 will NOT be harvested until sufficient funding is obtained.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

This program will develop new raspberry cultivars that are more productive or more pest resistant. Such cultivars may result from crosses made this year or may already be under evaluation. As a result of reduced funding, previously developed material will not be evaluated until sufficient funding is obtained.

PROPOSED BUDGET: Support is requested for a portion of the project operations budget at WSU Puyallup. Salaries for one WSU faculty member, 1.75 FTE support staff, and some operating funds (minus vehicle and phone charges) are provided by WSU for breeding work on BOTH strawberries and raspberries. This request provides for 0.15 FTE of a Plant

Tech II. This position was formerly fully funded by WSU and is now funded at 0.75 FTE. The remaining 0.10 of the cost of the position will be funded for 2002-2003 from other sources. This request also provides for 0.20 of an Agricultural Research Technician I. The remaining 0.40 of the cost of the position will be funded for 2002-2003 from other sources. The remaining funds in the request will be used for timeslip labor, field supplies, greenhouse supplies and travel to research plots and to grower meetings to present results of research.

The "Full Program" budget would provide for collection of harvest data from the 1998, 1999 and 2000 replicated yield plots, planting replicated yield plots with 2001 selections, and sowing the seed from 2001 and 2002 crosses in winter 2002-03.

Budget:		**Maintenance**	**Full Program**
Budget:	**2001-2002**	**2002-2003**	**2002-2003**
00 Salaries			
Plant Tech II 0.15 FTE		$5,250	$5,250
Agr. Res. Tech. 0.30 FTE	$9,665		10,023
Agr. Res. Tech. 0.20 FTE		6,682	
Lab Tech. 0.10 FTE	2,847		3,048
01 Timeslip Labor	12,500	3,000	18,000
03 Service and Supplies	5,521	1,000	4,997
04 Travel	500	400	500
07 Benefits			
Plant Tech II		1,418	1,418
Agr. Res. Tech.	3,595	2,640	3,960
Lab Tech 0.10 FTE	888		924
Timeslip	2,400	480	2,880
Total	**Requested $38,000**	**$20,870**	**$51,000**
	Funded $35,000		

Project: 13C-3755-7641

Title: Advanced Testing of Washington State University Raspberry Selections at Vancouver Research and Extension Unit

Personnel: Patrick P. Moore, Scientist, WSU Puyallup
Steve Klauer, Research Associate, WSU Vancouver

Reporting Period: 2001

Accomplishments:
A new replicated planting was established in 1999 of 12 clones including WSU 1068, WSU 1090, WSU 1098, and WSU 1112, promising selections that have not been tested at WSU Vancouver. The planting also includes WSU 1145, which appears to have root rot resistance, but in taste tests in 1999 did not rate highly for flavor. This planting was hand harvested for the first time in 2001. WSU 1068, WSU 1098 and WSU 1112 had the highest yields.

	yield (t/a)
WSU1068	6.3
WSU1098	4.9
WSU1112	3.4
WSU1145	2.9
Willamette	2.3
89-33-84	1.9
WSU1090	1.7
Tulameen	1.6
Qualicum	1.5
WSU1067	1.1
Meeker	0.8
85-18-16	0.3

A new raspberry planting was established at WSU Vancouver that was designed for machine harvesting evaluations. The new planting included BC 87-14-20 (released as Cowichan), WSU 1068, WSU 1090, WSU 1112, WSU 1161, WSU 1162 and Meeker as a standard. WSU 1161 will be trained to both a conventional trellis system and a split trellis system.

Publications:
Vancouver Field Day August 2001.

PROJECT NO.: 13C-3755-7641
TITLE: Advanced Testing of Washington State University Raspberry Selections at Vancouver Research and Extension Unit

PERSONNEL: Patrick P. Moore, Scientist, WSU Puyallup; Martin Nicholson, Operations Manager, WSU Vancouver.
YEAR INITIATED: 1996
CURRENT YEAR: 2002
TERMINATING YEAR: 2004

JUSTIFICATION: Developing a new raspberry cultivar is a long-term process. Promising selections are tested against standard cultivars in a replicated trial. If the selection performs well in this test, it then needs to be tested against standard cultivars in several locations throughout the region in which it will be grown. Accurate records of yield, fruit quality, susceptibility to pests at these locations is necessary in deciding to release or discard a promising selection. Many characters under genetic control are affected strongly by environment. Estimates of the effect of location on these characters will provide useful information that can improve the efficiency of a breeding program.

One of the most important characteristics to determine is the machine harvestability of a selection. There is no machine harvester at WSU Puyallup where most of the evaluation is conducted. WSU Vancouver has a current Littau harvester that can be used for evaluation of machine harvestability. A replicated planting was established in 2001 that was designed to evaluate machine harvestability.

OBJECTIVES:
1. To establish and maintain a replicated raspberry planting at WSU Vancouver Research and Extension Unit.

2. To measure yield, fruit quality, and susceptibility to pests in these selections as part of the ongoing cultivar development process with particular emphasis on evaluating machine harvestability.

PROCEDURES: This is an ongoing project that depends on continuity of effort. Each year promising selections are propagated for possible grower

trial. When several promising selections are identified, new test plantings are established.

1. A new replicated planting of raspberry clones for machine harvesting evaluation was established in 2001. Selections included were WSU 1068, WSU 1090, WSU 1112, WSU 1161, WSU 1162, and BC 87-14-20 along with Meeker for comparison. Four replications of twenty-five plant plots for each clone were planted at WSU Vancouver. The station now has a current Littau harvester and can evaluate the machine harvestability of selections. The primary objective of future plantings at WSU Vancouver will be to evaluate machine harvestability of selections.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:
New raspberry cultivars, which are more productive or more pest resistant, will be developed by this program. Such cultivars may result from crosses made this year or may already be under evaluation. The objective of this project is to make final evaluations of the most promising selections and to evaluate material from other programs. The most important evaluation will be evaluation of machine harvestability. WSU Vancouver now has a current Littau harvester that can be used for evaluation of machine harvestability. Research results will be communicated at grower meetings, commission meetings, and field days.

PROPOSED BUDGET: Support is requested for maintenance of raspberry plots at WSU Vancouver. This will include obtaining posts, wire, and herbicides.

Budget:	**2001-2002**	**2002-2003**
01 Timeslip Labor	4,750	$750
03 Service and Supplies	1,340	130
04 Travel	150	
07 Benefits	720	120
Total	**$7,000**	**$1,000**

Project: 13C-3755-8641

Title: Advanced Testing of Washington State University Raspberry Selections at Mt. Vernon Research and Extension Unit

Personnel: Patrick P. Moore, Scientist, WSU Puyallup
Gary Moulton, Scientific Assistant, WSU Mt. Vernon.

Reporting Period: 2001

Accomplishments:
A planting of 12 clones was established at WSU Mt. Vernon in 2000. It was maintained but will be converted into a demonstration planting. Subjective evaluations will be made, but no harvest data collected. WSU advanced selections in this planting are: WSU 1068, WSU 1112, WSU 1161 and WSU 1162.

The planting established at WSU Mt. Vernon in 1998 was harvested for the first time in 2000. ORUS 2078Y is a red fruited clone that was labeled as ORUS 2078, but when it fruited it turned out to be an unknown yellow fruiting raspberry. It was productive, firm, large fruited and late season. Although its identity is not known, there is interest in this raspberry. ORUS 2078Y and Tulameen were harvested in 2001.

	Yield (t/a)	Fr. Wt. (g)	Rot (%)	Midpoint of harvest
Tulameen	3.90	3.92	5.9%	7/19/01
ORUS 2078Y	4.99	4.80	10.3%	7/27/01

Publications:
Berry Field Day at WSU Mt. Vernon, July 19, 2001

PROJECT NO.: 13C-3755-8641

TITLE: Advanced Testing of Washington State University Raspberry Selections at Mt. Vernon Research and Extension Unit

PERSONNEL: Patrick P. Moore, Scientist, WSU Puyallup;
Gary Moulton, Scientific Assistant, WSU Mt. Vernon.

YEAR INITIATED: 1996
CURRENT YEAR: 2002
TERMINATING YEAR: 2003

JUSTIFICATION:
Developing a new raspberry cultivar is a long-term process. Promising selections are tested against standard cultivars in a replicated trial. If the selection performs well in this test, it then needs to be tested against standard cultivars in several locations throughout the region in which it will be grown. Accurate records of yield, fruit quality, susceptibility to pests at these locations is necessary in deciding to release or discard a promising selection. Many characters under genetic control are affected strongly by environment. Estimates of the effect of location on these characters will provide useful information that can improve the efficiency of a breeding program.

OBJECTIVES:
1. To establish and maintain a replicated raspberry planting at WSU Mt. Vernon Research and Extension Unit.

2. To measure yield, fruit quality, and susceptibility to pests in these selections as part of the ongoing cultivar development process.

PROCEDURES:
This is an ongoing project that depends on continuity of effort. Each year promising selections are propagated for possible grower trial. When several promising selections are identified, new test plantings are established.

A new replicated planting of raspberry selections was established in 2000. It includes WSU 1068, WSU 1112, WSU 1161 and WSU 1162, selections that have performed well at WSU Puyallup, but have not been adequately tested at WSU Mt. Vernon. Normally, this planting would be harvested for the first time in 2002. However, with reduced funding available, this planting will be maintained as a demonstration planting in 2002 and no data collected.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

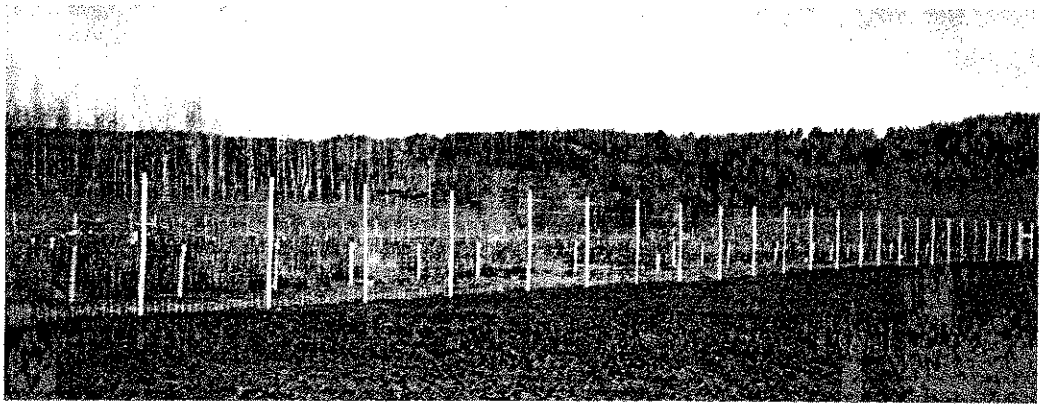
This program will develop new raspberry cultivars, which are more productive or more pest resistant. Such cultivars may result from crosses made this year or may already be under evaluation. The objective of this project is to make final evaluations of the most promising selections and to evaluate material from other programs. Research results will be communicated at grower meetings, commission meetings, and field days.

PROPOSED BUDGET:

Support is requested for maintenance raspberry plots at WSU Mt. Vernon. This will include obtaining posts, wire, and herbicides.

Budget:	**2001-2002**	**2002-2003**
00 Salaries		
Agr. Res. Tech 0.07 FTE	$2,107	$0
01 Timeslip Labor	2,000	300
03 Service and Supplies	728	152
04 Travel	150	0
07 Benefits		
Agr. Res. Tech.	695	0
Timeslip	320	48
Total	**$6,000**	**$500**
	$2,000 funded	

PROJECT: 13C-3755-6642
TITLE: Deer Fencing of Raspberry Yield Plots
PERSONNEL: Patrick P. Moore, Scientist,
WSU Puyallup Research & Extension Center, Puyallup, WA
Reporting Period:2001
ACCOMPLISHMENTS:
With the assistance of volunteers, an 8 foot tall, deer fence was constructed on Jan. 24 and 25, 2001. No deer damage was observed in 2001.



PROJECT NO: 13C-3555-5784

TITLE: ACHIEVING GREATER YIELD EFFICIENCY FOR WASHINGTON RED RASPBERRY PRODUCTION

PERSONNEL: **Stephen F. Klauer, Chuhe Chen**, Research Associates
WSU Vancouver REU

COOPERATORS: **Lynell K. Tanigoshi**, Associate Entomologist, WSUV REU
Peter R. Bristow, Associate Plant Pathologist, WSUP REC
Tom Peerbolt, Peerbolt Crop Management

REPORTING PERIOD: Termination report 2001

ACCOMPLISHMENTS: 2001

- Two simple and quick machine adjustments were tested for the third consecutive year in split trellis (ST) trials and again resulted in significant yield increases (greater than 20%) for the ST compared to the conventional trellis (CT).
- The primary problems with machine harvest of the split trellis thus far, damage to laterals and premature harvest of green fruit, were again minimized to commercially acceptable levels.
- No significant difference in insect/mite or fungal pests between trellis types was observed.

RESULTS:

Split Trellis Training System: Until recent years, narrow mechanical harvester architectures dictated the architecture of our current, rectangular canopy, which creates problems with light penetration, yield efficiency and harvest efficiency. Rotary harvesters with wider openings can accommodate wider trellises such as a split two-wire design, which increases light exposure. Our current canopy may lose 25% of its fruit to low light and since mechanical harvest losses can be in that range as well, our preliminary research led us to believe that this system could reduce both types of losses while making the plant more efficient and increasing crop sustainability.

Over the last four years, we have answered many questions concerning the performance of the split trellis. Over this timespan we have had 25 trials in northwest and southwest Washington comparing the split trellis (ST) vs conventional trellis (CT) in 'Meeker' red raspberry. These tested a variety of widths (28, 36, 43, 46, 51, 56, and 70 cm) = (11, 14, 17, 18, 20, 22, and 27 inches), crossarm styles and machine harvesters in fields with varied cultural practices. No differences were seen between treatments in machine harvest efficiency. In hand-picked and machine harvested trials, we have consistently demonstrated that widths 43 cm (17 in) or greater result in increased light penetration early in the season for ST, resulting in increases in leaf number (27-97%), leaf area (10-55%) and berry number (22-50%) per cane in the ST compared to the CT, particularly in the upper part of the canopy where more light is available. Increases in yield are consistently due to an increase in lateral number (24-26%) for the ST vs CT. Total aboveground biomass per cane is 20-33% greater

for ST and appears to be tightly controlled by the plant. Within the ST, increases in leaf number per cane and leaf area per cane are not reflected in a concomitant increase in total leaf dry weight, indicating an increase in canopy efficiency. The plant makes more leaves, but on average, they are smaller, thinner and distributed with the fruit in the wider upper canopy.

Leaf physiological measurements have not been significantly different between trellis types on a per leaf basis throughout the season, but there were differences between inner and outer leaves in both canopies, as outer leaves had greater chlorophyll, CO_2 assimilation rates, and more efficient light harvesting machinery. It is important to remember that this is very significant given that the split trellis has much more of its canopy exposed to light, thus on a per canopy basis the split trellis is more productive and efficient, thus its ability to increase yields. Having a greater number of leaves which are thinner but with the same physiological capacity creates potential efficiencies in the split trellis canopy which allow the plant to partition its resources elsewhere, and in this case as hoped, to fruit.

This increased productivity consistently results in estimated yield potential that is 20-60% greater for the split trellis. Actual machine harvested yields have varied from 0 to 33% greater for ST, but were more consistently in the 10-13% range until 1999, with yields being limited primarily by damage to laterals and premature pick of green fruit. In 1999, these problems were overcome by making two quick and easy adjustments to a Littau "over-the-row" vertical head harvester and resulted in a 19.4% increase in yield for ST in Lynden, WA. Spreading the picking heads early in the season, and then creaping them in as the season progressed minimized damage to laterals. Reducing beater speed until fruit quality was acceptable controlled premature pick of green fruit. In 2000, these adjustments were used for the first time in trials at WSUVREU, Burlington and Ridgefield, WA. Yields for the 17 and 20 inch STs ranged from 19.4 to 23% greater compared to the CT across the trials using adjustable head Littau harvesters.

We have shown increased yields for 2 or 3 consecutive years in ST trials in northwest and southwest WA. Based on these data, yields are sustainable with this trellis system.

Mite counts were done throughout the last two seasons. There were no significant differences in mite number/leaflet between trellis treatments, however, this year there was an indication (but not statistically significant) that the ST canopy may support predator populations in greater number later into the season (post harvest).

As in the previous years, no differences were seen in fruit rot between trellis types. This has been a key question to address. Our original hypothesis was that the canopy would have better air flow as the canopy is opened up by training canes to two wires. What we have observed is that the canopy is open early in the season and receives more light penetration, but the plant responds by producing more fruiting laterals in the top third of the canopy and more primocanes in the center of the canopy. This creates a dense, fruit enriched canopy with greatly increased yield. Fruit, representing both the processed market and the fresh market, has been harvested from each trellis type at northern and southern locations for 4 years and no significant difference has been observed between trellis types for fruit rot. The last two of

these years, rot was compared in rows treated and untreated with fruit rot preventative fungicides. No difference between trellis treatments was seen in sprayed or unsprayed trials.

Time of Floricane Removal. Our hypothesis in doing this study was that floricanes continue to contribute much needed carbohydrates to the root system after harvest to support the following year's crop. Our radioisotope experiments suggested this. To assess this, in previous years, replicated plots of canes were removed every two months starting at the end of harvest, and were then evaluated for yield and whole plant partitioning patterns in the following years. This year, two replications were inadvertently removed by pruning crews and we were forced to terminate this experiment. Effects of delayed pruning are likely cumulative over a period of years as more assimilates are partitioned to the crown system each year. If delayed pruning enhances the following year's yield, as we expect, the problem is quantifying this response in terms of practical implementation in light of potential short and long-term gain. We need more information to recommend a practice that may radically change the timing of labor needs.

Publications:

Klauer, S.F., Chen, C., Tanigoshi, L.K., and P.R. Bristow. 2001. The Machine-Harvested Split Trellis in Red Raspberry: 20% Increases in Yield, and a Study of Fungal and Spider Mite Dynamics. HortScience 36(3): 442.

Klauer, S.F., Chen, C., Tanigoshi, L.K., and P.R. Bristow. 2001. Further studies of machine harvested yields, fungal and spider mite dynamics in the split vs. conventional trellis in red raspberry. Proceedings of the 3rd Annual Small Fruit Grower's Workshop, Vancouver, WA, pp. 40-47.

Klauer, S.F., Chen, C., Tanigoshi, L.K., and P.R. Bristow. 2001. A comparison of yield, fruit rot and spider mites in the machine-harvested split vs. conventional trellis in red raspberry. Proceedings of the 43rd Annual Horticulture Growers' Short Course sponsored by the Lower Mainland Horticultural Improvement Association and the British Columbia Ministry of Agriculture and Food, Abbotsford, British Columbia, pp. 69-74.

Klauer, S.F. and C. Chen. 2000. Advanced development of split trellis system for red raspberry: cultural management and machine harvest studies. Proceedings of the Ninth Annual Conference of the USDA Northwest Center for Small Fruits Research, Kennewick, WA, pp. 49-50.

Title: Engineering resistance to raspberry bushy dwarf virus and Management of Tomato Ringspot Virus

Progress Report:

Personnel: Robert R. Martin and Jack Pinkerton, USDA-ARS Horticulture Crops Research Lab, Northwest Center for Small Fruit Research, 3420 NW Orchard Ave., Corvallis, OR 97330. Phone 514-750-8794, FAX 514-750-8764, E-mail martinrr@bcc.orst.edu pinkertonj@bcc.orst.edu & Helena Mathews, Exelixis Inc., Beaverton, OR.

During 2001 the 250 selections of transgenic 'Meeker' raspberry were evaluated for plant growth habit, fruit quality and graft resistance to RBDV. Many plants exhibited an off type growth in the field that was not observed in the screenhouse or greenhouse. Some plants were stunted, some had excessive blind bud in the spring, some had large leaves and some had crinkled leaves. For fruit, there were plants that had extremely crumbly fruit, others had fruit similar to 'Meeker' plants infected with RBDV. The resistance evaluations at this time are based on resistance to RBDV after double grafting in the greenhouse. Field resistance is being evaluated but will take longer field infections take 3-4 years. The plants that are being kept will be tested each year for RBDV as a means of evaluating field resistance. This process narrowed down the number of clones for further evaluation to 24. These 24 clones have been planted into a new block for further evaluations. The individual plots are larger so the material can be machine harvested to be sure the machine harvest characteristics of the 'Meeker' cultivar have not been altered.

In addition, 50 new transgenic lines of 'Meeker' have been developed. These plants contain mutated movement protein from tobacco mosaic virus. The reason for using this construct is that when it was inserted into tobacco it gave resistance to tobacco streak virus which infects raspberry and has many similarities to RBDV. These new transgenic lines will be planted in the field in the spring of 2002 both in Washington and in Oregon.

Washington Red Raspberry Commission

Title: Engineering resistance to raspberry bushy dwarf virus and Management of Tomato Ringspot Virus

Year Initiated 1996 Current Year 2002 Terminating Year 2004

Personnel: Robert R. Martin and Jack Pinkerton, USDA-ARS Horticulture Crops Research Lab, Northwest Center for Small Fruit Research, 3420 NW Orchard Ave., Corvallis, OR 97330. Phone 514-750-8794, FAX 514-750-8764, E-mail martinrr@bcc.orst.edu pinkertonj@bcc.orst.edu & Helena Mathews, Exelixis Inc., Beaverton, OR.

Justification:

With the decline of Willamette as the major raspberry cultivar in the Pacific Northwest we are seeing that RBDV is becoming more of a problem in raspberry plantings. Meeker, which is the most widely planted variety today, is susceptible to RBDV. Currently, only two raspberry cultivars (Willamette and Chilcotin) grown in this area are resistant to RBDV. Also, most advanced selections being evaluated in breeding programs in the Pacific Northwest are susceptible to this virus. Even with resistant varieties there is a new strain of the virus in Europe that is capable of overcoming the resistance, thus it infects varieties like Willamette and Chilcotin.

Transmission of RBDV is associated with flowering and therefore control is very difficult or impossible by chemical means. It is not clear at this time if the transmission occurs during the pollination process or if there are insects involved in the transmission (see accompanying proposal).

This project is of importance in Oregon and British Columbia as well as it is to Washington. RBDV is much more prevalent in red raspberry in Northern Washington and B.C. than it is in Oregon, however it occurs commonly in black raspberry in Oregon and at this time we are not sure of the reasons for the differences in the two areas. The transformation process will also be used in a related project that we are developing to engineer resistance to tomato ringspot virus in raspberry.

Tomato ringspot virus continues to be a problem in raspberry production in southern WA and in the Willamette Valley of OR. Even with soil fumigation, this virus reappears in fields within 3-4 years after planting. The reason for this is that soil fumigants only kill nematodes in the upper10-15 inches of soil. Any nematodes below the depth of effective fumigation will survive and if fumigant. The objectives are to develop effective alternatives to soil fumigation for control

of TomRSV and to develop a monitoring system that will be useful in evaluating the risk of TomRSV in a planting site based on the virus status of the nematodes present.carrying virus will be able to reinfect new raspberry plantings. The *Xiphinema* nematodes rarely reach levels to do any economic damage, the reason to control the nematodes is to control the virus. In addition to incomplete success with the soil fumigation, methyl bromide is being lost as a

Objectives RBDV:

1. Develop regeneration protocol for several Meeker red raspberry
2. Clone and sequence the coat protein of RBDV (completed).
3. Clone and sequence the movement protein of RBDV (completed).
4. Carry out mutagenesis of movement protein of RBDV (completed).
5. Transform raspberry with coat protein, movement protein and mutated movement protein genes of RBDV.
6. Test transgenic plants for virus resistance in the greenhouse (graft inoculations started in October of 1998). Continued in 1999 and 2000. Many of the lines have been grafted twice with RBDV.
7. Test transgenic plants in field trials for virus resistance and fruit quality (Set up first field trials in 1999). Applications approved in 1998 and 1999 and 2000.
8. Develop new transgenics with mutated movement protein of tobacco mosaic virus, this construct gave resistance to tobacco streak which has similarities to RBDV. These plants will be ready to go in the field in 2002. The mutations have been done and transformations are almost completed.

This year we will be addressing objectives 6, 7, 8. Objectives 1-5 have been completed.

Objectives TomRSV:

1. Develop methods to detect tomato ringspot virus (TomRSV) in nematodes, ELISA, reverse transcription-polymerase chain reaction (RT-PCR), immunocapture RT-PCR, and immunofluorescence microscopy will be used to determine which is the most sensitive method to detect virus in nematodes.
2. Monitor the reinfection of TomRSV in raspberries following a 18 month rotation with cover crops (monocot and brassicaceous), fallow, and fumigation.
3. Evaluate raspberry plants that have been genetically engineered for resistance to TomRSV. Replicated blocks of each clone will be evaluated

in field plots and plants will be graft-inoculated in a screenhouse.

Objectives 1 and 2 have been the focus of work the past several years. The detection needs some fine tuning and will be worked on more this year. The transgenic plants should be planted in 2002.

Procedures:
This project requires a significant amount of tissue culture for plant propagation and regeneration, and laboratory supplies (enzymes, RNA and DNA extraction kits, and various detection assays for analysis of transgenic plants. Transgenic plants (plants with inserted gene) will be tested for resistance to RBDV in both greenhouse and field tests. Greenhouse tests will involve grafting of the transgenic plants with known sources of RBDV. Field tests will be used to determine rate of infection (if any) under field conditions and to ensure that no changes in fruit quality have resulted from the transformation process. When these plants are developed we will also try to have them tested for resistance to the new strain of RBDV in Europe (this will be done in collaboration with colleagues in the UK). Methods to detect DNA, RNA and proteins will be used to ensure the genes are inserted and to ensure that the genes are expressed in raspberry plants (with the exception of the nontranslatable RNA constructs).

Anticipated Benefits and Information Transfer:
Virus resistance will increase the life of raspberry plantings by eliminating the crumbly fruit symptom and yield losses caused by this virus. The regeneration and transformation protocols have been used to transform raspberries with the constructs of Tomato Ringspot Virus (TomRSV).
Results will be made available to the growers via presentations at growers meetings and viewing of field plots as they are available.

Budget:

Amount allocated in 2001	15,000
Request for 2002	5,000
Salaries	3,000
Supplies	2,000

Due to reduced funding available from the commission in 2002 we have pared back the proposal requests. We anticipate getting some funding from the Oregon Caneberry Commission, The BC Raspberry Industry Development Council and the Northwest Center for Small Fruit Research to help offset the short fall. The projects will go ahead

Progress Report

Principal Investigators: Robert R. Martin and Dr. Jack Pinkerton, USDA-ARS Horticulture Crops Research Lab, Northwest Center for Small Fruit Research, 3420 NW Orchard Ave., Corvallis, OR 97330. Phone 514-750-8794, FAX 514-750-8764, E-mail martinrr@bcc.orst.edu and pinkertj@bcc.orst.edu

In fall 1998, plots were established in 0.5 acres area of raspberry field in Vancouver, WA with plants symptomatic of TomRSV. Before the plants were removed, leaves and soil samples were collected to map the distribution TomRSV and *Xiphinema ameicanum*, respectively. Four treatments; perennial grass maintained weed-free, rape (canola), clean fallow, and raspberry with mixed grass-weed ground cover in alleys, have been established in randomized block design with five replicates. The perennial grass and rape, although hosts for *X. americanum,* are not hosts for TomRSV. Thus, TomRSV should be eliminated from the plots planted with these crops. Soil has been collected monthly and assayed to quantify nematode populations and to determine the persistence of TomRSV in the nematodes with a cucumber assay protocol described below. The plots were planted with red raspberry in spring 2000. Field plots planted with different cover crops have been monitored for Xiphinema populations monthly for the past 2 years. Nematodes have been collected and fed on trap plants in the greenhouse to monitor virus content. 'Meeker' red raspberry plants were put into a plot that was maintained weed free for two years. This plot will be used to study movement of TomRSV within rows and between rows with different types of cover crops. 'Meeker' red raspberry has been transformed with the coat protein and nontranslatable RNA from tomato ringspot virus (TomRSV). The plants are in tissue culture and in the process of being rooted. This has gone slower than expected, therefore the plants will be put in the field in 2001. They will be planted into a site that is heavily infected with TomRSV and has high numbers of the vector *Xiphinema americanum* in replicated blocks.

Experiments to detect TomRSV directly in *X. americanum* are being conducted. ELISA tests have not been successful and efforts have concentrated on PCR. Using reverse transcription-polymerase chain reaction (RT-PCR) we have been able to detect the virus in nematodes but not consistently. This work is continuing, using different methods to extract virus or viral RNA from the nematodes.

Project No.
Title: Red Raspberry Cultivar Development for the Pacific Northwest

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Reporting period: 2001

Funding: In 2000/2001 funds were received from the BC Raspberry Industry Research Council, Washington Red Raspberry Commission, Lower Mainland Horticultural Improvement Association (LMHIA), royalties collected on PARC cultivars and Agriculture and Agri-Food Canada's Matching Investment Initiative (MII).

Accomplishments: In 2001 the PARC breeding program released Cowichan, a new variety that shows resistance to RBDV. It has vigorous canes with large firm fruit that will machine harvest. Approximately 2,500 new seedlings were planted from 88 crosses made in 1999 and 2000. Forty-two new crosses were made with RBDV resistance clones. Sixty-two PARC selections were planted in replicated and unreplicated plots. Twenty-seven of these were advanced selections and thirty-five were new selections being planted in the field for the first time. Seventeen other clones were also planted. These included control varieties as well as new releases and advanced selections from other breeding programs. Sixty-eight new selections were made from the 1998 seedling planting. Of these, 63 have been chosen for yield and observation trials in 2002 and 3 will be used for breeding. Two others are early derivatives of *R. strigosus* and *R. idaeus* that were screened for resistance to *Phytophthora fragariae*. They also all have high levels of resistance to the aphid *A. agathonica*. These two selections will be tested for resistance to root rot and RBDV and used in future crosses.

During the 2001 harvest season the 1996, 1997, 1998 and 1999 plantings were evaluated. Data on yield, fruit traits and harvest season is presented for each planting year in tables 1a-c and 2.

The selection 90-11-44, from a cross between Algonquin and Tulameen, produced the highest yield in the 1996 planting. It tested well for ease of harvest and has spineless canes, with short laterals that bend easily, perhaps making it suitable for machine harvesting. The fruit is large enough for processing with dark, firm, fine drupelets and a very pleasant flavour, somewhat similar to Chilliwack. In the 1997 planting, selections 89-34-41 followed by 89-2-89, 92-5-52 and 92-5-1 produced the highest yield. Selection 92-5-1 produce attractive fruit, which was dark in colour and appears to be very suitable for processing. Selections 89-2-89, 90-8-20 and 91-15-40 had exceptionally large fruit size. In the 1998 planting, 92-4-5 followed by 92-4-11, 91-17-10 and 92-7-43 produced the highest yield. 90-6-2 followed by 92-4-11 had the largest fruit size. The 1999 planting was harvest for the first time with some new selections tested for the first time and producing exceptionally high yield. More data is required to assess them.

Notes on cultivars and potential new cultivars:

Qualicum (Glen Moy x Chilliwack)
Has large firm fruit that well adapted for fresh market and long distance shipping. For the last few years, experience has shown that under proper growing conditions Qualicum can be adaptable to mechanical harvesting, and its fruit acceptable for IQF and the processing market. However, under vigorous growing conditions Qualicum produces excessive growth, making this variety unsuitable for mechanical harvesting and very susceptible to pre-harvest fruit rot. Qualicum shows an excellent level of winter hardiness, somewhat similar to Haida.

Malahat (Meeker x BC/SCRI 7853/116)
Produces high yields of large, firm fruit that ripens up to a week earlier than any other recommended variety and is well suited to the fresh market. It should be particularly useful for the early fresh market where early production and good quality are important. In grower trials, Malahat was suitable for machine harvesting producing a high quality IQF and processing crop. Because Malahat ripens earlier than Meeker, it has allowed the producer a longer harvest season and a better utilisation of harvesting equipment. Plants of Malahat are susceptible to root rot, therefor it should be planted on well-drained soil that is free of root rot. Canes have small spines over most of the cane surface. Laterals are short. Fruit is very easy to harvest. It is susceptible to RBDV but the rate of infection appears to be slow. Malahat is resistant to the aphid vector of the raspberry mosaic virus complex.

Kitsilano (Comox x EM 3909/4)
A newly named selection that is a very late ripening and is suited to the fresh market. The fruit is medium size, glossy medium red, very firm and easy to harvest. It has relatively small drupelets, good flavour, some resistance to both pre- and post-harvest *Botrytis*-incited rots and an extended harvest season. It ripens later than Tulameen with an overlap in some years with early primocane fruiting varieties. The plant produces high yields with a moderate numbers of canes, having some spines but not objectionable. Its winter hardiness is similar to Meeker and less than Chilliwack. Kitsilano is relatively susceptible to spur blight (*Didymella applanata*), cane botrytis (*B. cinerea*), root rot (*P. fragariae* var. *rubi*) and RBDV (although the rate of infection appears to be slow). It is resistant to the aphid vector of the raspberry mosaic virus complex.

Cowichan [tested BC87-14-20 (Newburgh x Qualicum)]
The most newly name PARC cultivar. Cowichan appears to be a very promising option to escape the infection of RBDV. Its parent the Newburgh, variety was introduced in 1929 from a cross made between Newman x Herbert. It is not a very productive variety and has small fruit, but it is resistance to both RBDV and root rot and it is relatively winter hardy. When Newburgh was combined with Qualicum's high productivity, large fruit size and good fruit quality, the cross was very successful. Although it has not been confirmed and more testing is needed, Cowichan plants tested in greenhouse trials showed a very good resistance to root rot. In the research plots it was very vigorous, very fast to establish and producing high yields after the first year of planting. At the Abbotsford sub station site it was moderately productive, and produced attractive large fruit that was firm, glossy and had acceptable flavour and aroma (Tables 1 & 2). In a grower's field trial, although exposed to RBDV, it has so far tested negative to RBDV, while Meeker and other PNW varieties grown in the same field have shown very high infection rate. In the same trial for the last two years it showed that it is very suitable for mechanical harvesting. It produces an acceptable yield of large fruit that ripens a few days earlier then Meeker and fruit that appears to be suitable for IQF. Plant growth is very vigorous with an upright habit and good 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*).

BC89-2-89 (Comox x Glen Ample)

Produces high yields of large fruit (5.6 g) that is 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 PNW recommended variety. Fruit is larger than Tulameen, light in colour with large droplets. The plant is a very vigorous, with strong spineless canes and strong long upright lateral. It will not machine harvest. Fruit is very meaty, heavy and drupelets tend to break upon harvest. It is not resistant to RBDV but appears to have slow rates of infection. It is susceptible to cane botrytis (*B. cinerea*) and at this time reaction to root rot is unknown.

BC89-33-84 (BC82-5-84 x Tulameen)

A mid season processing and fresh market type that produces attractive dark berries with some resistance to fruit rot. The fruit is easy to harvest and in some growers' trials has machine harvested well. Fruit is glossy, large, firm, perfect in shape with fine drupelets, and so is very suitable for IQF. The plant has excellent vigour. 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 but appears to have a slow rate of infection.

BC89-34-41 (BC82-5-161 x BC80-28-50)

Selected from a cross between two PARC selections. This is an early fresh market or processing selection producing high yields with fruit size larger than Meeker. It is very productive producing a high yield of large firm fruit that have a very pleasant flavour comparable to Chilliwack. Fruit is smaller than 89-33-84. The canes are spineless with laterals that are short and bend easily without breaking and so are able to carry the high yield. In a grower trial the fruit did not release well from the receptacle and was not suitable for mechanical harvesting.

BC90-6-2 (BC86-41-15 x BC83-15-15)

Selected from a cross between a root rot resistant *R. strigosus* derivative and a selection from a cross between Comox and Algonquin. We had noted it for its short internodes, compact plant habit, extremely late production season and its very large meaty fruit. It produces numerous primocanes, but has been rated as being hard to harvest. BC90-6-2 is most suitable for the fresh market due to its long harvest duration, late producing period and large fruit.

New selections for grower trials:

BC90-8-11 (BC86-41-15 x Qualicum)

This is a 3rd backcross from *R. strigosus*. It that produces a large mid to late crop that is most suited for the fresh market. The fruit is large, firm and is well spaced and presented on the laterals. The plant has an upright habit.

BC90-8-20 (BC86-41-15 x Qualicum)

A productive selection that has a mid-season production period with light fruit that is most suitable for the fresh market but also acceptable for IQF and processing. The large low-gloss fruit strongly resembles Qualicum. Plant vigour is not excessive; leaves are large and light. It is resistant to aphids and might be also resistant to the resistant-breaking biotype of aphid.

BC90-11-44 (Algonquin x Qualicum)

This is a very productive selection that produces over an extended harvest season good size fruit that is firm and attractive with very fine drupelets. It is easy to harvest and appears suitable for processing and fresh market.

BC92-5-1 (Kitsilano x BC86-40-6)

This selection is high yielding and produces a long-shaped, mid-size dark, glossy berry that is most suitable for processing. It has low susceptibility to fruit rot. The plant has light coloured leaves and vigorous canes with long laterals and some spines.

A limited number of plants from this list will be available for trials from Sakuma Bros. in Burlington, WA., Tel.: (360) 757-6611, and Ken M. Spooner Farms, Tel.: (253) 845-5717. You are encouraged to plant and test some of these experimental trial selections. During the growing season visit the experimental plantings at the Abbotsford Sub-Station, 510 Clearbrook Rd., Abbotsford. Tel.: (604) 853-1551.

Table 1a. Yield, fruit weight, harvest season and harvest ease of raspberry cultivars harvested in 2001, Abbotsford, BC.

CLONE	No. of plots	Total Yield (kg/hill)	Total Yield (t/ha)	Early Yield[z] (%)	Late Yield[y] (%)	Fruit Rot (%)	Fruit Weight (g)	First Harvest (date)	50% Harvest (date)	Harvest Duration (Days)	Harvest Ease[x]
1996 planting											
87-11-33	1	4.43	15.9	34.9	1.8	0.3	4.0	4-Jul	16-Jul	34	2.3
87-12-11	1	5.67	20.3	11.2	1.6	0.5	3.6	8-Jul	16-Jul	30	2.0
87-12-32	1	4.40	15.8	13.4	1.1	0.3	3.6	8-Jul	16-Jul	22	2.0
87-14-16	1	5.13	18.4	7.4	3.7	1.1	4.2	8-Jul	22-Jul	30	2.0
87-14-20	2	4.02	14.4	9.8	3.0	1.2	4.6	9-Jul	19-Jul	29	2.1
87-3-37	1	2.96	10.6	2.8	6.9	0.7	3.9	11-Jul	22-Jul	33	2.5
87-5-1	3	3.22	11.6	0.4	4.0	0.4	4.7	14-Jul	22-Jul	21	2.6
89-33-84	3	3.79	13.6	10.3	4.7	0.3	3.8	9-Jul	20-Jul	29	2.2
89-34-41	3	5.03	18.0	5.4	5.2	0.8	3.4	11-Jul	22-Jul	29	2.4
90-11-44	1	6.84	24.6	8.0	10.0	1.0	3.3	11-Jul	22-Jul	33	2.0
90-5-30	1	3.66	13.1	27.5	1.1	0.6	5.3	4-Jul	16-Jul	26	2.0
90-8-11	1	5.14	18.4	0.6	3.6	0.3	6.5	16-Jul	22-Jul	22	3.0
Chilcotin	1	3.31	11.9	10.9	6.8	2.9	3.6	8-Jul	22-Jul	30	2.0
Chilliwack	3	2.15	7.7	6.9	0.6	0.7	3.5	11-Jul	22-Jul	19	2.4
Comox	1	4.08	14.6	7.7	1.6	1.2	4.3	11-Jul	16-Jul	19	2.5
Kitsilano	3	5.67	20.3	2.4	12.4	0.4	3.4	12-Jul	24-Jul	34	2.3
Malahat	3	3.99	14.3	24.5	4.0	0.3	4.4	6-Jul	16-Jul	33	2.5
Meeker	3	3.08	11.0	7.9	0.3	0.2	3.1	10-Jul	22-Jul	20	2.3
Nootka	1	2.43	8.7	26.0	0.0	0.6	3.0	8-Jul	16-Jul	22	1.3
Qualicum	3	4.61	16.5	11.3	1.6	0.4	5.1	9-Jul	20-Jul	26	2.4
Tulameen	3	3.41	12.2	5.3	7.9	1.4	4.7	11-Jul	22-Jul	31	2.4
1997 planting											
89-2-89	2	6.25	22.4	0.3	17.6	0.5	5.9	16-Jul	29-Jul	28	2.5
89-33-84	3	4.69	16.8	13.3	5.1	0.5	4.3	8-Jul	20-Jul	30	2.2
89-34-41	3	6.84	24.5	7.3	6.8	0.5	3.6	10-Jul	22-Jul	32	2.2
89-6-12	2	4.29	15.4	17.2	1.1	0.4	4.7	8-Jul	19-Jul	22	2.0
89-6-13	1	4.33	15.5	1.5	20.9	0.9	4.5	16-Jul	29-Jul	35	3.0
90-8-20	1	5.02	18.0	5.4	1.2	0.9	5.8	11-Jul	19-Jul	21	2.5
91-15-40	3	4.50	16.1	16.3	5.3	0.4	5.6	6-Jul	20-Jul	31	2.3
92-10-27	1	3.86	13.9	26.4	0.0	0.7	3.7	4-Jul	16-Jul	26	1.3
92-10-53	3	4.55	16.3	27.2	2.5	0.9	4.5	5-Jul	18-Jul	27	2.4
92-5-1	3	6.02	21.6	6.7	4.7	0.4	4.5	11-Jul	22-Jul	27	3.1
92-5-52	2	6.24	22.4	6.0	7.6	0.8	4.2	9-Jul	22-Jul	35	3.0
92-9-12	1	3.14	11.2	2.4	9.0	0.3	5.5	11-Jul	22-Jul	33	2.0
ORUS1072-11	1	4.15	14.9	36.3	0.0	0.4	4.0	4-Jul	16-Jul	22	1.7
ORUS 870R-12	1	3.85	13.8	11.8	0.0	1.5	4.1	8-Jul	16-Jul	22	2.8
WSU 1068	3	4.24	15.2	28.2	0.8	0.9	4.7	4-Jul	16-Jul	29	3.1
WSU 1090	1	6.50	23.3	2.1	5.7	0.7	5.3	11-Jul	22-Jul	27	2.0
WSU 1099	1	6.22	22.3	4.3	15.8	0.7	4.7	11-Jul	22-Jul	33	2.0
CHILLIWACK	3	3.80	13.6	6.3	0.6	0.3	3.7	11-Jul	22-Jul	22	2.2
COHO	1	4.08	14.7	1.1	16.3	2.4	4.0	11-Jul	29-Jul	40	2.0
MALAHAT	3	4.36	15.6	32.1	5.1	0.3	4.8	4-Jul	16-Jul	34	2.4
MEEKER	3	4.68	16.8	2.9	2.6	0.4	3.5	11-Jul	22-Jul	27	2.4
QUALICUM	3	5.29	19.0	10.5	2.9	0.6	5.9	9-Jul	22-Jul	29	2.1
TULAMEEN	3	5.81	20.8	3.8	13.9	1.1	5.4	11-Jul	22-Jul	38	2.2
LSD		1.79	6.4	14.2	6.2	2.6	0.7	4	6	8	0.9

Plants were grown in hills with a 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 5 ft. Data from replicated plots was subjected to analysis of variance, with least significant difference (LSD) of 5 % used to separate means. [z]Early Yield harvested between July 5 and July 12, 2001. [y]Late Yield harvested after August 12th 2001. [x]Harvest ease was rated on four harvest dates, 1=easy, 5=hard.

Table 1b. **Yield, fruit weight, harvest season and harvest ease of raspberry cultivars harvested in 2001, Abbotsford, BC.**

CLONE	No. of plots	Total Yield (kg/hill)	Total Yield (t/ha)	Early Yield[z] (%)	Late Yield[y] (%)	Fruit Rot (%)	Fruit Weight (g)	First Harvest (date)	50% Harvest (date)	Harvest Duration (Days)	Harvest Ease[x]
1998 planting											
89-33-84	3	3.95	14.2	16.5	8.8	0.6	4.1	6-Jul	22-Jul	33	2.0
90-6-2	1	5.14	18.4	9.2	14.0	1.2	5.8	8-Jul	22-Jul	43	2.8
91-17-10	2	5.42	19.4	10.2	9.5	1.8	4.7	8-Jul	21-Jul	37	2.5
91-17-11	2	5.32	19.1	7.3	11.0	1.3	3.9	9-Jul	25-Jul	35	2.4
91-24-12	1	4.24	15.2	18.4	0.7	0.4	5.0	8-Jul	16-Jul	22	2.7
91-28-4	3	3.56	12.8	9.2	3.7	0.8	3.6	9-Jul	20-Jul	27	2.2
92-10-53	3	3.46	12.4	8.4	7.0	0.8	3.6	10-Jul	22-Jul	30	2.5
92-20-17	3	3.02	10.8	39.6	1.8	0.4	3.8	4-Jul	14-Jul	25	2.2
92-4-11	3	5.72	20.5	25.4	4.2	1.0	5.3	6-Jul	18-Jul	33	2.5
92-4-49	3	5.32	19.1	46.1	4.8	1.1	4.7	4-Jul	14-Jul	30	2.2
92-4-5	1	6.87	24.7	14.7	7.1	0.6	4.3	8-Jul	18-Jul	36	2.0
92-6-17	3	4.35	15.6	18.1	2.0	0.8	4.7	7-Jul	20-Jul	27	2.2
92-6-41	3	4.38	15.7	12.9	2.1	0.3	4.1	9-Jul	22-Jul	26	2.0
92-7-43	2	4.51	16.2	3.8	22.8	4.5	3.3	13-Jul	29-Jul	33	3.2
92-9-15	1	4.82	17.3	44.9	5.1	1.4	4.6	4-Jul	16-Jul	34	2.0
92-9-33	3	3.59	12.9	44.5	1.1	0.9	4.3	4-Jul	14-Jul	26	2.2
92-9-57	3	4.37	15.7	46.4	1.7	1.2	4.7	4-Jul	12-Jul	26	2.6
MEEKER	3	3.54	12.7	3.7	5.2	0.3	3.2	11-Jul	25-Jul	29	2.5
1999 planting											
84-12-22	1	4.83	17.3	17.9	1.8	0.9	3.3	4-Jul	22-Jul	34	2.3
87-14-20	3	3.70	13.3	24.3	1.2	1.2	4.0	4-Jul	18-Jul	29	2.1
87-14-35	2	3.85	13.8	16.9	17.7	3.8	4.3	6-Jul	24-Jul	43	1.5
87-5-1	2	3.23	11.6	22.4	0.9	1.9	3.9	4-Jul	21-Jul	29	2.3
87-9-6	1	7.66	27.5	18.8	2.1	0.7	3.6	7-Jul	16-Jul	29	2.0
89-2-89	2	4.08	14.6	10.1	3.4	0.7	3.4	6-Jul	22-Jul	32	2.8
89-33-84	4	5.70	20.5	37.2	3.6	1.2	3.6	4-Jul	15-Jul	31	2.3
89-34-41	3	6.85	24.6	6.8	11.0	2.1	3.3	9-Jul	23-Jul	35	2.0
89-6-12	3	3.47	12.5	29.7	3.3	4.1	3.9	4-Jul	16-Jul	31	2.2
90-4-23	1	4.14	14.9	53.1	0.7	1.9	3.6	4-Jul	11-Jul	26	2.0
90-6-2	2	4.85	17.4	21.0	29.5	3.1	5.2	4-Jul	25-Jul	54	2.2
90-8-20	2	4.41	15.8	19.7	3.1	6.4	4.6	6-Jul	19-Jul	28	2.3
91-26-26	3	4.28	15.4	6.3	9.2	1.5	3.6	10-Jul	24-Jul	32	1.9
92-10-39	1	9.99	35.8	11.9	13.7	3.7	4.2	4-Jul	22-Jul	40	2.8
93-1-32	2	5.48	19.6	9.9	3.7	1.1	3.6	6-Jul	22-Jul	32	2.8
93-31-19	1	8.23	29.5	6.4	24.3	1.5	3.6	11-Jul	29-Jul	40	2.3
93-34-18	2	7.99	28.7	10.8	11.4	2.5	4.1	8-Jul	22-Jul	38	3.0
93-34-81	1	5.76	20.7	21.4	4.7	1.3	4.1	8-Jul	16-Jul	30	2.0
93-35-27	2	5.33	19.1	14.7	3.1	0.5	5.2	6-Jul	18-Jul	30	2.1
93-36-10	1	4.28	15.4	24.9	8.4	0.8	4.0	4-Jul	16-Jul	40	2.8
93-36-31	1	7.35	26.4	44.6	1.0	1.1	3.2	4-Jul	16-Jul	26	2.8
93-4-3	1	2.00	7.2	46.5	1.9	7.3	3.4	4-Jul	11-Jul	26	2.4
COHO	1	5.20	18.6	3.2	11.5	0.9	3.9	11-Jul	22-Jul	33	2.8
KITSILANO	2	7.98	28.6	7.9	18.8	1.6	2.9	7-Jul	25-Jul	38	2.3
MALAHAT	3	5.00	17.9	36.0	2.9	0.9	3.8	4-Jul	16-Jul	29	2.2
MEEKER	3	4.25	15.3	25.1	0.7	0.7	3.2	4-Jul	16-Jul	27	2.3
NOOTKA	3	2.99	10.7	45.8	0.6	0.3	3.1	4-Jul	12-Jul	25	1.1
QUALICUM	3	7.27	26.1	13.5	4.8	1.3	4.3	6-Jul	20-Jul	29	2.3
TULAMEEN	3	6.67	23.9	14.5	7.2	1.6	4.7	7-Jul	19-Jul	39	2.3
LSD		1.79	6.4	14.2	6.2	2.6	0.7	4	6	8	0.9

See table 1a for footnotes.

Table 2. Fruit traits of raspberry cultivars harvested in 2001,

Abbotsford, BC.

Clone	Firmness[z] (g/cm^2)	Soluble Solids Concentration[y] (%)	Fruit Rot After 48 hrs[y] (%)
87-14-20	183	9.8	42.2
89-2-89	226	9.7	25.0
89-33-84	226	10.8	18.8
89-34-41	128	10.5	29.7
89-6-12	150	10.3	23.4
90-4-23	135	13.0	.
90-6-2	144	8.7	67.2
90-8-20	188	10.2	42.2
91-15-40	149	10.8	53.1
91-17-10	157	10.3	.
91-17-11	122	11.1	.
91-24-12	142	9.9	39.1
91-26-26	126	12.2	.
92-10-39	113	9.5	.
92-10-53	129	9.2	45.3
92-20-17	117	11.0	61.6
92-4-11	205	9.4	26.6
92-4-49	166	11.2	40.6
92-5-1	130	9.5	23.4
92-5-52	145	8.9	42.2
92-6-17	177	10.5	26.6
92-6-41	127	11.3	.
92-7-43	180	8.5	.
92-9-15	178	12.5	42.2
92-9-57	176	11.8	.
93-34-18	193	11.2	.
93-35-22	151	11.7	.
93-35-27	161	11.2	53.1
93-36-31	105	10.4	65.6
Chilliwack	231	11.7	31.3
Coho	210	11.0	4.7
Kitsilano	157	9.4	12.5
Malahat	183	10.0	14.1
Meeker	122	10.4	53.1
Nootka	94	10.9	17.2
Qualicum	206	9.9	.
Tulameen	178	11.2	25.0
LSD	64	2.3	22.6

Data was subjected to analysis of variance, with least significant difference (LSD) of 5 % used to separate means.
[z]Firmness, the force required to close the opening of the fruit, was obtained for 10 fruit from two harvests.
[y]Means of 10 fruit from two harvests.

Project No:

Year Initiated: 2001 **Current Year:** 2002 **Terminating Year:** 2005

Title: **Red Raspberry Cultivar Development**

Personnel: Chaim Kempler and Hugh Daubeny
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Project Description:
Develop red raspberry selections stressing suitability for machine harvesting, dark fruit, winter hardiness, and resistance to RBDV, root rot, and aphids. Of particular importance is to speedup the release of cultivars that can replace Meeker with cultivars that are disease and pest resistant.

Justification:
The Agriculture and Agri-Food Canada (AAFC) breeding program supports the berry industry throughout the Pacific Northwest (PNW) and produces varieties that enhance production. Of particular importance are 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 and can be simply controlled by resistance to the 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 and this has complicated the screening procedure. There is a need for genes that give resistant to resistance-breaking aphid biotype, or identify more universal resistance genes to 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 common strain of the RBDV virus has been controlled by breeding for resistant cultivars. Of cultivars released from the program in the past, Haida is resistant to RBDV and Nootka, and Chilcotin although not known to be resistant, never tested positive to RBDV and likely have very good tolerance and do not get infected with the virus. The recent release and naming of Cowichan (BC87-14-20) has given some hope to the industry that there is a cultivar that is suitable for mechanical harvesting, that escapes RBDV and stand to root rot. More than 6,000 plants were test planted in 2001 across the PNW and more will be planted in the coming years. The plantings will be evaluated by the growers for their production and suitability for their operation.

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 from such cross, that has root rot resistant and appears to be suited for mechanical harvesting and processing. It has been propagated and will be tested in growers' trials.

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, cultivars with 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 using parents that were derived from various species. Germplasm from other breeding programs around the world is used. This germplasm is tested and used to incorporate desirable traits. Also, a wide range of wild species is used. The last three cultivars released (Tulameen, Qualicum and Malahat) have the black raspberry, *Rubus occidentalis* L., in their derivation. In addition, Malahat has *R. phoenicolasius* Maxim. Some of the potential cultivars that are now in growers' trials have *R. occidentalis* in their derivation. Kitsilano has *R. crataegifolius* in its derivation, and BC 90-6-2 has the 'Dalhousie Lake' selection of *R. strigosus* Maxim. 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:
Develop red raspberry selections stressing suitability for machine harvesting, dark fruit, winter hardiness, resistance to root rot, resistance to divergent aphid biotypes, and RBDV.

- Winter hardy plants that withstand low temperatures and desiccating winds throughout winter months, and/or late breaking dormancy.
- Manageable plant habit that is suitable for machine harvesting and produces high yields.
- Aphid resistance, which controls the Raspberry Mosaic Virus Complex (RMVC).
- Superior fruit quality, which includes flavour, size, firmness, ease of harvest, and rot resistance.
- Processing fruit needs to be dark and have high acidity and soluble solids content.
- Resistance to pollen infection from the raspberry bushy dwarf virus (RBDV).
- Resistance or tolerance to root rot (*Phytophthora fragariae)*, and lesion nematodes.
- Resistance or tolerance to cane diseases (such as spur blight, cane *botrytis* and cane spot), spider mites, bacterial blight and crown gall.
- Resistance to leaf diseases such as rust and powdery mildew.
- Adequate replacement cane production.

Procedures:
Experimental Details:
This will involve- harvesting of sound and rotted fruit, 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:

- 2002 crossing blocks -continue backcross on the F1 to F3 rot root resistance selections, using RBDV resistance parents.
- Evaluation of the seedling population that was planted in 1999 and 2000.
- Establish replicated trials to assess advanced selections suitable for processing and machine harvest.
- Evaluation of advanced selections in growers' fields to assess productivity, machine harvesting, and resistance to root rot and RBDV.
- Supervise distribution of advanced selections to North American propagators, growers and subsequently monitor their performance.
- Evaluate Cowichan, BC89-2-89, BC89-33-84, BC89-34-41, on growers' trials.
- Propagation of BC90-8-11, BC90-8-20, BC90-11-44, BC90-19-34, BC92-5-1 for PNW growers' trials.

Anticipated Benefits and Information Transfer:
The results of the evaluations will be directly available to the red raspberry industry in the PNW. In the coming year the evaluations will help determine if selections like Cowichan, BC89-2-89, BC89-33-84, BC89-34-41, BC90-6-2 and others are commercially suitable.

Budget: Amount requested from the WRRC for FY 2002: $US 8,000. ($US1=$CD1.5)
The Washington State Red Raspberry Commission contribution could be matched by Agriculture and Agri-Food Canada Matching Investment Initiative (MII) funds with up to $12,000.

Resource commitments:

Research assistance	$ 18,200
Summer students (5 x $7,500)	$ 37,500
Land preparation (fertilizer, field fumigation, etc.)	$ 10,000
O&M (drip irrigation, trellis, etc.)	$ 6,800
Travel	$ 3,000
Total	**$ 75,500**

Other collaborative partners (committed funding in 1998-2000):
Raspberry Industry Development Council (RIDC)
Lower Mainland Horticultural Improvement Association (LMHIA)

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Project No.: 13C-3761-5253

Title: Survey of red raspberry propagation fields for Phytophthora root rot: A pilot project.

Personnel: Peter R. Bristow, Associate Plant Pathologist, WSU Research and Extension Center-Puyallup
Thomas L. Wessels, Plant Services Program Manager, Washington State Department of Agriculture, Olympia

Cooperators: Sakuma Bros. Farms, Burlington, WA
Spooner Farms, Lacey, WA

Reporting Period: 2001

Accomplishment: Nearly 1600 root samples were collected in fall 2000 and tested for *Phytophthora* spp. by ELISA at the WSDA laboratory in Prosser, WA. Each root sample was assigned a random code number and was divided into two portions. One portion went to the WSDA lab. The other portion was frozen for later testing at an Agriculture and Agri-Food Canada laboratory that uses DNA sequencing methods to identify the species of *Phytophthora* and/or *Pythium* in the roots.

From the work thus far, it is clear that the particular ELISA test used detects *Pythium* as well as *Phytophthora*. The false positives can be identified when the DNA method is used to test the frozen root samples. In surveying plants in propagation beds, false negatives are more of a concern because roots testing negative actually harbor the root rot fungus. If the frequency of false negatives is high, the ELISA test will be of little value in screening samples from plant nurseries.

Until we can work around this problem, the decision was made not to collect samples in fall 2001*. We will continue to work with the lab in Canada to test more of the frozen samples collected in 2000. Also, we are looking into developing a molecular probe that would be specific for *Phytopthora fragariae* var. *rubi*. Funds approved for 2001-02 will be carried forward to the 2002-03 fiscal year.

Background: There is concern within the red raspberry industry that root rot caused by the soil-borne fungus *Phytophthora fragariae* var. *rubi* is spreading through the planting of symptomless but infected/contaminated stock. The

disease has appeared in replanted field where the disease was not present before. The very rapid spread of this disease in both Europe and Australia is thought to be due in large part to plants becoming infected in plant nurseries. This pilot project was the outcome of a meeting held in October, 1999 in Lynden, WA, This meeting was attended by red raspberry growers, plant propagators, WSDA personnel who implement the plant certification program and research and extension personnel from WSU and USDA who work directly with the red raspberry. This project was to survey plant production fields using ELISA technology for the detection infected plants. Information from the project is needed before any changes in the rules and standards, as they relate to this root disease, are made.

Objectives:

1. Determine if the Phytophthora root rot is present in fields used for the propagation of certified red raspberry plants using an ELISA based test for the detection of infected plants.
2. Develop sampling methods that might become part of the rules and standard for certification of plants if needed.

Budget:

Request for FY	**2001-02**	**2002-03**
Timeslip labor	$2,000	
Operations (goods and services)	2,400	
Travel		
Projected needs	500	
Meetings	250	
Equipment	300	
Employee benefits	320	
Total	**$5,470**	**0**

*The exact position of every sample collected to date was recorded by a GPS unit. This means we can go back to the very spot (within a few inches) where every sample was taken at any time in the future. A recent survey of commercial red raspberry fields in British Columbia found four species of *Phytophthora* (*P. cinnamomi*, *P. megasperma,* and *P. cactorum* in addition to *P. fragariae* var *rubi*) in roots. This means that frozen roots samples should be tested for the three other species as well.

Until the pilot project is completed, it was agreed that: 1) the results for a given cooperating nursery will be shared only with the designated representative for that nursery and 2) only the lead investigators will have access to uncoded information.

Other support for the project:

None at this time.

Project No.: 13C-3761-4251

Title: Investigating rates and sources of gypsum to reduce damage from Phytophthora root rot in an integrated control program.

Year initiated: 2001 **Terminating year:** 2004

Personnel: Peter Bristow, Associate Plant Pathologist and Gwen Windom, Agric. Res. Tech. III, Washington State University, Puyallup Research and Extension Center

Reporting year: 2001

The start of this project was postponed until the 2002 crop season. The reason for the delay was two fold: 1) the quantity of the type of planting stock needed was not available and 2) the desire to leave the test site fallow for one year. The site has been used continuously for root rot studies since the early 1980's; the most recent trial was concluded in late fall 2000.

Justification: Root rot, caused by the soil-borne fungus *Phytophthora fragariae* var. *rubi*, is the most serious root disease of red raspberry in the Pacific Northwest. Based on earlier research, it is clear that no single control measure or method will provide the level of control required for this high value crop. An integrated program incorporating several methods will be required. Recently we demonstrated that mixing high rates of agricultural gypsum into infested soil prior to planting helped to control the disease. The level of control was enhanced when gypsum is used in combination with raised beds and the application of metalaxyl (Ridomil and more recently Ridomil Gold). Fosetyl-Al (Aliette) also has activity against *P. fragariae* var. *rubi*, but it has not been as effective as metalaxyl. Newer fungicides have been tested but even if promising products are identified, it will be years to move them through the approval process. Efforts to breed for the high level of resistance needed for effective disease control have been frustrating. Even the most resistant source identified to date yielded more when treated with metalaxyl. Progress is being made in combining resistance with desirable horticultural traits, but it takes time and there are no shortcuts.

Questions regarding the use of gypsum remain. The most frequent question is "do you need to apply 6 tons of gypsum per acre to be effective?" Other questions include: "how often does gypsum need to be reapplied?" and "can less expensive forms of gypsum, such as recycle wall board, be used?" The objectives of this research will address these questions.

Objectives:

1. In a field planting in naturally infested soil, test different rates of agricultural gypsum for control of this root disease. The planting will be made on raised beds.
2. Develop greenhouse methods for evaluating the effectiveness of gypsum in controlling disease.
3. Evaluate different sources of gypsum including recycled wallboard where the paper backing has been removed before recycling.

Procedures: A field trial will be established on a site with a history of Phytophthora root rot. Two susceptible varieties will be planted (one will be Meeker). Agricultural gypsum will be applied to the soil and work in as the raised beds are shaped. Soil from the different treatments will be monitored for pH and the concentration of the calcium ion. Plant growth, yield and disease incidence and severity will be assessed yearly.

Naturally infested field soil and other soils artificially infested with the fungus will amended with gypsum in greenhouse experiments to establish a method for testing the effectiveness of gypsum. Developing a greenhouse potted plant test in the long run will be more efficient that field-testing.

Anticipated Benefits and Information Transfer: Testing different rates of gypsum will help to maximize disease control while keeping the cost of using gypsum at a minimum. Identifying non-chemical control measures should help to maintain the useful life of traditional fungicides that are registered for this use. Because soil types that are ideal for growing red raspberries are limited, sites that become infested with the pathogen could still be used to grow the crop.

The results of this field study and others investigating different aspects of this disease will be presented at grower meetings, workshops, and field days. The information will also be disseminated through local and regional publications including the Pacific Northwest Plant Disease Control Handbook and the Pest Management Guide for Commercial Small Fruits. Demonstration plots may also be established on the farms of cooperating growers.

Budget:

	2001-02	2002-03
Timeslip labor	3800	
Operations (goods and services)	1000	
Travel		
Project needs	300	
Meetings	100	
Equipment	1300	
Employee benefits	610	
Total	**$7110**	**$0**
	$5000 funded	

Other Support of Project: None at this time but support will be requested from different gypsum suppliers.

Project No.: 13J-3543-4977

Title: Evaluation of Novel Insecticides for the Rational Control of the Orange Tortrix

Personnel: **Lynell K. Tanigoshi**, Associate Entomologist,
Jeanette R. Bergen, Agricultural Research Technologist II,
Washington State University, Vancouver Research & Extension Unit
Tom J. Peerbolt, Peerbolt Incorporated DBA Peerbolt Crop Management

Reporting period: 2001 (Terminal report)

Accomplishments: A 16 acre block of evergreen blackberries was subdivided into 0.67 acre plots that were randomized to include six treatment, each replicated four times. Treatments included an untreated check, three rates of Confirm (tebufenazide) and two timing regimes. Application rates were 0.03, 0.06 and 0.25 lb (AI)/acre. The sticker Latron B-1956 was added to the tank mix at 2 oz/100 gal. All five treatments were applied on 22 May to 24 randomized plots. The second Confirm spray was applied on 13 June. This mid-June application is traditionally applied to control second generation orange tortrix larvae during the preharvest period.

Foliage samples were taken from the above field trials to assess the residual persistence of Confirm to immature instars of the orange tortrix. Five 3rd instar larvae were placed on individual field collected leaves whose stem-end was placed in a small water-filled vial stoppered with a cotton plug. These arenas were placed in individual Petri dishes, replicated five times and held at 68 ^{o}F. These field collected blackberry leaves were sampled at 1, 3, 8, and 10 day posttreatment. Mortality was examined at multiple intervals for 14-15 days after larvae were placed on specific field aged residues of Confirm.

Pesticides were applied in aqueous suspensions using a Precision Spray Tower with 1 ml of each concentration uniformly applied to both surfaces of each red raspberry leaf. Nu-Film P at 2 oz/acre was added to each solution. Each leaf was air-dried and the stem-end placed in a small water-filled vial stoppered with a cotton plug. These were placed in 6 inch Petri dishes with three 3rd instar orange tortrix larvae. Each test was replicated ten times and mortality was measured at 1, 2, 5, 7, 9 and 12 days posttreatment.

Results:

Sixteen days after applying specific rates of Confirm to 20 plots, visual counts of all rolled leaf shelters of solitary orange tortrix larvae were taken in all of the plots. Compared with the untreated check, the mean number of feeding shelters were significantly different in the single treatment plots at 0.03 lb (AI)/acre and the 0.25 lb (AI)/acre plots treated on 22 May and 13 June. The remaining 3 treatment schedules were different from the check but not at the 5% level of significance. Further research is suggested to improve timing based on orange tortrixs' seasonal phenology during their second generation. Optimum timing for the specific mode of action for Confirm is when larvae emerge from eggs and begin to feed.

Residual control for Confirm, based on the field applied rates of 0.03, 0.06 and 0.25 lb (AI)/acre, on blackberry foliage was evaluated from the above field trial after the first 22 May spray. The results clearly support the registrants claim that Confirm will provide 14 to 21 days of residual control in the field and that larvae stop feeding within a few hours. Initial mortality was observed after 24 hours exposure at the three field rates. Levels of 84 to 100% mortality were observed after 15-17 days of feeding exposure across 1 to 10 days posttreatment for blackberry during early bloom. Leaves bioassayed with 10 day-old residues of low and high rates of Confirm provided equivalent larval mortality after 22 days of field deposition. This lab bioassay and field assessment of larval activity indicate that the lower rates of Confirm are above the lower threshold rate needed to attach to the target site of action for ecdysone.

The registered pyrethroids, Asana and Brigade continue to provide quick contact and stomach knockdown at 2 days posttreatment and 100% mortality after 5 days exposure on blackberry foliage. The experimental biorationals Proclaim and Success provided excellent larval control after 5-6 days after treatment. Both of these compounds are highly effective against lepidopteran larvae and are defined as low risk and OP alternative pesticides by the EPA. Because of Confirm's mode of action as a molting hormone inhibitor, the 3 rates of this registered insecticide provided lethal disruption of the molting process 9-12 days after exposure to rates as low as 0.06, 0.12 and recommended field rate of 0.25 lb (AI)/acre. The eventual registration of Success and possibly Proclaim would provide excellent selectivity along with Confirm to delay development of resistance and they would provide ideal alternatives to the broadspectrum pyrethroids.

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Project No.: 13C-3543-5272

Title: Further Studies on the Biology, Phenology and Control of Root Weevils on Red Raspberry

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

Reporting period: 2001 (Terminal report)

Accomplishments: Several promising biorational or reduced risk insecticides and those EPA call OP alternatives were tested in the laboratory at recommended field rates on the black vine, strawberry and rough strawberry root weevils. This was the second year we conducted these bioassays with a precision Potter Tower. One of these, the neonicotinoid Actara was identified for priority "A" performance studies for 2001 on caneberries. The insect growth regulators Dimilin and Distance showed modest species selectivity for adult control. This year's bioassays further reinforced our understanding that the root weevil complex in Washington red raspberry respond differently to both the recommended field rate for Brigade and several promising new experimental insecticides. After nearly a decade of consistent usage, multiple lab bioassays for different populations and species of root weevils to Brigade are showing trends toward increased weevil tolerance. This trend further underscores the urgent need to register new mode of action insecticides. Adequate numbers of seasonal black vine, strawberry, rough strawberry, clay-colored and obscure root weevils were collected to further detail their ovipositional period and seasonal fecundity. This knowledge will provide pest managers with a biological tool to affect a well-timed preovipositional application for summer generation weevils and for the earlier emergence of overwintering adults from the previous season. If adult weevils are controlled before egg laying begins in the field, their potential in-field increases from one season to the next will be reduced.

Results: The proposed objective to field trial the above mentioned insecticides for black vine weevil control was not conducted because adequate levels of preharvest weevil populations were never located or reported. Though not significant at 7 to 14 days posttreatment, we observed differential responses by root weevil species to Brigade (bifenthrin) and the experimental neonicotinoids in Petri dish bioassays during the critical 1-7 days posttreatment interval. The initial knockdown by Actara and Assail is generally not as rapid as Brigade. When their

efficacy is compared with last year's lab data, trends for their variable activity between species and season is still apparent. The ovicidal activity of Dimilin (diflubenzuron) and Esteem (pyriproxyfen) resulted in BVW laying fewer and more infertile eggs compared with the untreated ones. These trends confirmed results we reported in 2000. Reproductive trends for mature overwintering and summer emerging black vine weevils from Woodland and Vancouver, respectively, confirmed the need to monitor and control late winter emerging adults. These data further confirm the effectiveness of our current practice of applying a preharvest application of Brigade to knockdown summer emerging weevils that are mostly still in their pre-egg laying stage. Petri dish studies in the lab averaged a mean accumulation of 481 eggs/weevil (25 overwintering weevils) over a period extending from 23 April to 22 October and 669 eggs/weevil (30 summer weevils) from 25 June to 15 October. Newly emerged, teneral (soft bodied) clay-colored weevil collected from the Northwood Area near Lynden in early April began laying eggs in the lab around 21 May. In the same field, overwintered black vine and rough strawberry root weevil were also collected, thought not as numerous as the clay-colored weevil. Twenty-five adult clay-colored weevils laid and average of 98 eggs/weevil through late August. This was a 3-fold increased compared with clay-colored weevil fecundity we reported for the previous two years in the Northwood area and extended the duration of the egg laying period by over two months. These data indicate that an early April basal application of Brigade will control all three species of pre-egg laying root weevils under ideal coverage conditions. For some unknown reason, the teneral rough strawberry root weevils collected at the Norwood field averaged only 6 eggs/weevil during a very short ovipositional period of about two weeks. The less common spring emerging obscure root weevil began laying eggs in late may and ceased oviposition by the end of July. This Woodland population of obscure root weevil laid 26 egg/weevil or nearly 4-fold less than we reported in 1999 for a Whatcom County population.

Expanding our knowledge about the basic biology of the root weevil complex in Washington State will provide growers and fieldmen with better species specific parameters. This understanding will help them make better chemical application decisions before their respective weevil or complex has begun to lay their eggs in the soil and on foliage. Further knowledge about selective tolerances by different weevil species to current weevil recommendations will result in increased efficiency and productivity. New registrations of insecticides with different modes of action and when used as part of a rotational program will prolong the development of resistance or potential to flare-up spider mites.

Publications:

Tanigoshi, L. K., C. Chen and G. W. Menzies. 2000. Control an economic impact of the clay colored weevil on red raspberry. Research Reports: 59th Annual Pacific Northwest Insect Management Conference, 3-4 January 2000, Portland, OR, pp. 61-63.

Tanigoshi, L. K., J. D. Chamberlain and G. W. Menzies. 2000. Clay colored weevil insecticide efficacy trials on raspberry, 1999. Arthropod Management Tests, Vol. 25, electronic publication @ Entsoc.org.

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Tanigoshi, L. K. 2000. Managing root weevils in Washington State berries. Informal Conference: Innovative Arthropod Management for Small Fruits. 2000 JAM, Societe d'entomologie du Quebec, Entomological Society of Canada and Entomological Society of America, 3-6 December 2000, Montreal, Canada.

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Tanigoshi, L. K. and J. R. Bergen. 2001. Control and fecundity of root weevils in red raspberry. 60th Annual Pacific Northwest Insect Management Conference, 8-9 January 2001, Portland, OR, pp. 95-98.

Tanigoshi, L. K. 2001. Everything you need to know about weevils. 43th Annual Horticulture Growers' Short Course, 15-17 February 2001, Abbotsford, BC, pp. 78-80.

Tanigoshi, L. K. 2001. Managing root weevils in Washington berries. 3rd Annual Small Fruit Growers' Workshop Proceedings, 22 March 2001, Vancouver, WA, pp. 1-4.

Tanigoshi, L. K. 2001. Managing root weevils in Washington State berries. 8th International *Rubus* and *Ribes* Symposium, 9-11 July 2001, Dundee, Scotland, Abstract.

Tanigoshi, L. K. and J. R. Bergen. Managing root weevils in Washington State red raspberries. ACTA Horticulturae (in press).

Project No.: 13C-3755-5967

Title: Integrated Research on Red Raspberry in Northwestern Washington: Entomology, Plant Pathology, Breeding and Horticulture

Personnel: Co-Principal Investigators

Lynell K. Tanigoshi, Associate Entomologist, WSU Vancouver REU
Stephen F. Klauer and **Chuhe Chen**, Research Associates, WSU Vancouver REU
Peter R. Bristow, Associate Plant Pathologist, WSU Puyallup REC
Patrick P. Moore, Plant Breeder, WSU Puyallup REC

Cooperator:

Craig MacConnell, Chair, Whatcom County WSU Cooperative Extension

Reporting period: 2001 (Terminal Report)

Accomplishments:

Weekly mite brushing samples were taken from replicated single (CT) and split trellis (ST) plots to ascertain if there were ecological and physiological effects of canopy architecture and nitrogen levels on the population dynamics of yellow spider mite, *Eotetranychus carpini borealis* on 'Meeker' in Burlington, WA.

Mite brushing data taken in 2000 and 2001 clearly indicate that population levels of the two spider mite are not significantly increased by opening up the canopy of mature 'Meeker" plants with the split trellis system.

Several new aphicides were evaluated and two of them hold promise for federal registration on red raspberry within a couple of years.

Two quick and simple adjustments made to a Littau "over the row" harvester resulted in increased yields of over 20% for a 20 inch wide ST compared to a CT for a second consecutive year in a Burlington, WA trial.

Several types of fruit rot were assessed in the split trellis trial. Training fruiting canes to two top wires opens the canopy early in the season and we wanted to see if this would reduce the incidence of fruit rot when compared to the conventional single top wire trellis.

Results: In 2001, yield of the ST vs CT was again compared in "Meeker" red raspberry. A 20-inch ST with metal crossarms was compared to a CT in a grower's field for a second consecutive year. A Littau "over the row" harvester with a 50 inch throat was used for harvest. Similar to previous years, we optimized machine harvest of ST by spreading the picking heads early in the season and gradually moved them in as the season progressed, thereby reducing lateral damage early in the harvest. Harvest of excessive green fruit was avoided by adjusting the beater speed until fruit quality was acceptable. Yields from the ST were 21% greater than from the CT. After three years of using these machine adjustments, it is clear that yields of 20% or greater can be consistently obtained with the ST using adjustable Littau harvesters. A ST width of 20 inches seems ideal, but last year we reported similar success with a 17 inch ST using a "siderow" Littau machine with a 39 inch throat. Yield increases of this magnitude (around 20%) will generally increase profits for growers by approximately 15% per acre/yr after deducting increased costs attributed to the ST.

At Burlington, for the last two years, rot was compared in rows treated and untreated (except for a single application of captan early in bloom) with fruit rot preventative fungicides. To assess the incidence of fruit rot in ST vs CT, two types of berries were harvested by hand on each of three dates. One sample consisted of fully ripe berries that would be harvested mechanically for processing. For the second sample, berries were picked fully colored but underripe (pink) as they would for the fresh market. Only berries without rot symptoms were picked. The fully ripe berries were incubated individually for three days at 100% relative humidity and then evaluated for the incidence of mold. Berries at the fresh market stage of ripeness were held for six days in clamshell packs and then evaluated. Storage conditions during the six days mimicked conditions berries might encounter in fresh marketing channels.

In the sample representing processed berries, *Cladosporium*, a general contaminant found in red raspberries, was the most common fungus on moldy berries. The incidence of *Botrytis cinerea* was very low on the first harvest, but was higher at the second and third harvests. At these two harvests, the incidence of *B. cinerea* was; a) not influenced by the type of trellis and b) slightly lower for plots treated with fungicides. *Penicillium* and *Rhizopus* were only present at the third harvest and the incidence of both was very low.

No significant differences in fruit rot were found between trellis types in the treated vs untreated trials. While we had hypothesized that a more open split canopy might improve air flow and reduce fruit rot, it appears that the plant responds by making a larger canopy with more laterals in the upper third of the

canopy and more primocanes filling the void in the center of the row. Even though this canopy is larger, we have never observed any difference in fruit rot between trellis types in four years of data collection and analysis.

Mite populations were monitored in the ST vs the CT in Burlington, 2000. Thirty waist high to upper canopy leaflets were randomly taken from six 30 foot long plots randomly placed in 6 rows of CT and 6 rows of ST 'Meeker' red raspberry in Burlington. Leaflets were taken from floricanes for the first 5 sampling dates and switched to primocanes for the 26 July sample. There were no significant differences detected between the 2 trellis treatment's yellow spider mite population levels during the preharvest and harvest periods. However, the potential for a significant late season population increase was indicated for the split trellis samples taken after 26 July. Given the obvious visual and quantified increase of leaf numbers in the ST canopy compared with the CT, the number (biomass) of yellow spider mites in the ST is probably much higher than in the CT canopy. This, though the yellow spider mite densities were more or less statistically the same.

In 2001, yellow spider mites populations were monitored in the same split trellis field as in 2000. The field design consisted of six 60-foot long plots randomly placed in 6 rows of CT and 6 rows of ST. Weekly samples consisted of 50 eye level leaflets taken between a two post section of each row, 25 primocane leaflets per side of row. Both treatments received the traditional preharvest Brigade clean-up spray and fruit rot fungicides. Population levels of the yellow spider mite between the two trellis schemes were not significantly different for the four sampling dates in July. Furthermore their levels remained below the provisional economic level of 25 spider mites per leaflet. However, by 2 August, mite levels numerically increased by 3.4 and 4.7 fold for the split and single trellis rows, respectively. On 10 August, motile life stages of the yellow spider mite on the split trellis rows increased by 1.5 and remained at that level on 16 August. The general trend for the single trellis showed a stable increased on 10 August followed by a slight 1.2-fold increase of motile stages on 16 August. Statistically, there was no significant difference between the yellow spider mite population dynamics between the two cultural systems for 'Meeker" red raspberry. This effect is strongly influenced by the common observation that mid-season spider mite populations are often highly aggregated within and between sampling site in a given field. Of special importance was the delayed density dependent response of the phytoseiid predator, *Neoseiulus fallacis* to exceptionally high levels of 5-6.6 per leaflet. No doubt the impact of this natural enemy was reflected in the stable population increase observed for yellow spider mite life stages during the month of August. The question about how beneficial these predators are in

suppressing postharvest yellow spider mite remains to be researched for red raspberry.

Five aphicides were evaluated for efficacy to control late summer raspberry aphid on a first-year 'Meeker' red raspberry field in 2000. Treatments were applied on 2 August with a tractor mounted six-tank plot sprayer using 12 D3-45 TeeJet nozzles arranged on an over the row boom at 100 psi to deliver 69 gpa at 3 mph. Plots were single row and 60 feet long, separated by one post length and replicated five times. Compared with the untreated check and malathion, the experimental neonicotinoids Admire (imidacloprid), Actara (thiamethozam) and Assail (acetamiprid) provide quick knockdown at 2 and 12 day after treatment. The two experimental rates of the highly selective and systemic Fulfill showed no knockdown effect until after 2 days posttreatment. These results for Fulfill are in agreement with its unique mode of action whereby aphids stop feeding shortly after exposure and mortality occurs from starvation after 2-5 days. We are enthusiastic about the results obtained with the neonicotinoid class of insecticides and specific insecticides with modes of action that are targeted to pest species. The neonicotinoids, imidacloprid (Provado/Admire) and thiamethoxam have undergone residue data collection and Bayer and Syngenta, respectively, have submitted data packages to EPA for blueberry, caneberries and strawberry registrations in 2002 and 2003. Both of these insecticides are excellent aphicides.

Publications:

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Bounfour, M. and L. K. Tanigoshi. 2001. Host plant-mediated interactions between *Tetranychus urticae* Koch and *Eotetranychus carpini borealis* (Ewing)(Acari: Tetranychidae). Exp. Appl. Acarol. 25: 13-24.

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Project No: 13C-3543-3272

Title: Control and Economic Impact of the Clay Colored Weevil on Red Raspberry.

Personnel: **Lynell K. Tanigoshi**, Associate Entomologist,
Chuhe Chen, Research Associate,
Washington State University, Vancouver Research & Extension Unit
Todd Murray, IPM Project, WSU Whatcom County Cooperative Extension

Reporting period: 2001 (Terminal report)

Accomplishments: Because of the career change by Dr. Chen earlier in the year, we were unable to further evaluate the impact of clay-colored weevil bud damage on red raspberry yield components and its association with cold damage and spur blight. We concluded that an integrated pest management would provide tools that would assist growers in avoiding the cumulative damage to red raspberry fruiting buds and has special importance in areas where cold injury frequently occurs. Lab bioassys and an abbreviated field trial in 2001 confirmed good efficacy of the neonicotinoid insecticides, Actara (thiomethoxam) and Assail (acetamiprid). A label for Actara in strawberry and blueberry may be available in 2003. We will push for residue data collection in caneberries via IR-4 in 2002.

Results: The combined damage from cold injury with infestations of clay-colored weevil and spur blight to bud damage was 42% and 58% yield loss per hectare after three and six weeks compared with 34% for the clay-colored treated check. The combined damage was well over the compensatory ability of red raspberry and resulted in lower lateral numbers per cane, lower fruit numbers per cane and fruit weight. Bud damage by clay-colored weevil in the spring left little time for the secondary laterals to initiate flowers. Field trials in 2001 were terminated after the 7 day posttreatment count because the grower sprayed over our replicated plots. However, at 7 days posttreatment, over the row applications of the neonicotinoid Actara and Brigade were equally outstanding compared with the untreated check. Basal application of Assail, Brigade and Guthion were intermediate to the two over-row applications while basally applied Actara was significantly less effective than the above treatments. When these field trials were applied on 26 April 2001, the canopy was further advanced compared with earlier timings when the field trials were conducted about two weeks earlier when lateral foliage was on 1-2 inches long. It is well documented that mature clay-colored

weevils will remain in the canopy for several days during the cool days in April and May.

Publications:

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Tanigoshi, L. K. 2001. Managing root weevils in Washington State red raspberries. ACTA Horticulturae (in press).

Project No: 13C 3419 3297

Title: Caneburning and Weed Control in Red Raspberries

Personnel: Timothy W. Miller, Extension Weed Scientist, WSU Mount Vernon
Stephen F. Klauer, Chuhe Chen, Research Associates, WSU Vancouver
Carl R. Libbey, Research Technologist, WSU Mount Vernon

Reporting Period: 2001-02

Accomplishments:

Results have been collected after two full years in effort to evaluate the long term effects of three caneburning compounds (Goal, Enquik, and Aim) in combination with or without Casoron in 'Meeker' red raspberry. Replicated plots were treated with the following rates: Casoron (4 lbs ai/a) alone or in sequential combination with Goal (0.4 lb ai/a), Aim (0.1 lb ai/a) or Rely (1 lb/a), and the same rates of Goal, Aim, and Rely alone (without Casoron).

Results:

1. After two years of treatments, raspberry response to herbicides was not clear. Certain treatments in certain replicates showed significant decline, but the same treatments in other reps remained healthy. In particular, in two plots of Aim used alone (reps 1 and 3), raspberries showed marked stand injury, while Aim plots (in reps 2 and 4) showed no significant decline. Since the Casoron + Aim combination treatment caused only very slight or no raspberry injury in the four reps, it appears that raspberry decline at this site has not correlated well with herbicide application.

2. Burn was reasonable for all treatments and most pronounced with Goal, alone or with Casoron. Primocane regrowth was also slowest when Casoron was combined with the caneburning materials compared to the untreated check or Casoron alone. Aim and Rely burned well, but were softer on the plant and intermediate between Goal and the check in terms of primocane number or height. Casoron + Aim had less of an impact on cane regrowth than the combination of Casoron with Rely or Goal. Raspberries treated with Casoron + Rely and Casoron + Goal had significantly shorter primocanes in July, but by mid-August, differences between most treatments for primocane height were not statistically significant. While the range in primocane number at the end of harvest was large, only primocanes in the Goal + Casoron treatment were significantly shorter than nontreated canes.

3. Casoron improved weed control comapared to caneburning products used alone.

4. There were no significant differences in machine-picked yield between treatments.

Project No: 13C 3419 3297

Title: Caneburning and Weed Control in Red Raspberries

Year Initiated: 2000-01 **Current Year:** 2002-03 **Terminating Year:** 2002-03

Personnel:

Timothy W. Miller, Extension Weed Scientist, WSU Mount Vernon
Carl R. Libbey, Research Technologist, WSU Mount Vernon

Justification:

Herbicides have been widely used for years to suppress raspberry primocane growth in the spring. Caneburning is primarily conducted to aid in the mechanical harvest of berries, but an enhanced level of weed control within the crop row is a side benefit to the herbicide application. Controlling primocane growth may also force raspberry plants into partitioning more photosynthates into berry production and less into vegetative growth. Many raspberry growers, however, suspect that herbicides currently being used for this purpose may be leading to a decline in raspberry plant vigor after several years of use.

Potential caneburning chemicals should have at least four characteristics. 1. They should be contact herbicides (i.e., foliar-active materials that are not translocated into plant roots). 2. They should be short-residual products that are either non-mobile in soil or have only minimal root uptake, to prevent potential injury to raspberry plants. 3. They should not easily volatilize, which could cause injury to foliage on the floricanes. 4. They should offer some degree of weed control in the crop row, with herbicidal activity on weed species that are problematic in western Washington raspberry production.

This weed control aspect of caneburning herbicides used in raspberries should not be overlooked. In particular, control of the perennial weed species becomes more important the longer raspberry blocks are left in production. Horsetail (*Equisetum* spp.), quackgrass *(Elytrigia repens)*, broadleaf dock (*Rumex obtusifolius*), Canada thistle (*Cirsium arvense*), dandelion (*Taraxacum officinale*), and hedge bindweed (*Calystegia sepium*) have long been weedy in western Washington. A newly introduced species with tremendous weedy potential is yellow nutsedge (*Cyperus esculentus*). If not controlled, these perennial weeds can be a major factor in reducing the longevity of raspberry plantings.

Objective: Conduct testing of primocane suppression products at various rates and in tank mixtures, evaluating them by their efficacy, weed control, and crop safety over a three-year time frame. This would be the third and final year of this 3-year project.

Procedures:

Long-term plots established at WSU Vancouver in 1999-2000 will continue to be evaluated for the effects of Goal (oxyfluorfen), Aim (carfentrazone), and Enquik (monocarbamide dihydrogensulfate) used to control primocane growth of raspberry. Products will be applied with or without Casoron (dichlobenil, applied during the dormant season) in the upcoming growing season (2001-02). Effect of the products on primocane suppression, weed control, and berry yield will be evaluated. Yield will be estimated using a machine harvester. During each week of harvest, the weight of 50 berries will also be recorded. At midsummer and harvest end, primocane numbers will be recorded. Annual yield component analysis will demonstrate alterations in plant reproductive effort resulting from caneburning programs during the given year, as well as over time.

Anticipated Benefits and Information Transfer:

These studies will improve primocane suppression practices in raspberries by adding to the knowledge of growers when they make decisions regarding herbicide selection and application. Data from this experiment will be used to support new herbicide registrations in raspberries and to fine-tune existing labels. 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:

	Requested 2002-03
Time-slip	$ 5,000
Operations (goods & services)	1,000
Travel	
Projected Needs	500
Meetings	0
Other	0
Equipment	0
Employee Benefits (16%)	800
Total Request	$ 7,300

NOTE: The budget would be split between WSU Mount Vernon and Vancouver.

Other Support of Project:

Herbicides are typically provided by herbicide manufacturers. Additional funding for the testing will be requested from the manufacturers of those herbicides.

Current & Pending Support

Timothy W. Miller

Extension Weed Scientist, WSU Mount Vernon

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
	Current:				
	WA Com. Pest. Reg.				
Miller & Libbey	10A 3093 2437	$ 6,225	7/1/01 to 6/30/02	5	Weed control in newly planted strawberries
Miller & Libbey	10A 3093 2436	5,100	7/1/01 to 6/30/02	5	Weed control in spinach and table beets grown for seed
Miller & Libbey	10A 3093 2438	3,940	7/1/01 to 6/30/02	5	Weed control in organic strawberries
	WA Bulb Com.				
Miller & Libbey	13C 3419 4228	10,950	2/1/01 to 1/31/02	10	Weed control in ornamental bulbs
	WA Blueberry Com.				
Miller & Libbey	13C 3419 5229	4,230	7/1/01 to 6/30/02	5	Weed control in blueberries
	WA Strawberry Com.				
Miller & Libbey	13C 3419 8228	10,120	7/1/01 to 6/30/02	5	Weed control in strawberries
	WA Raspberry Com.				
Miller, Klauer, & Libbey	13C 3419 3297	12,000	7/1/01 to 6/30/02	5	Weed control in raspberries
	NARF				
Miller & Libbey	13K 3419 5228	8,710	7/1/01 to 6/30/02	10	Weed control in green peas
Miller & Libbey	13K 3419 6228	7,966	7/1/01 to 6/30/02	10	Weed control in cucumbers
Miller & Libbey	13K 3419 7228	10,450	7/1/01 to 6/30/02	10	Weed control in vegetable seed
Miller & Libbey	WA Com. Pest. Reg.	$ 1,790	7/1/02 to 6/30/03	5	Weed control in organic strawberries
Miller & Libbey	WA Com. Pest. Reg.	6,510	7/1/02 to 6/30/03	5	Weed control in cauliflower using shielded sprayer
Boydston, Miller, & Yenish	WA Com. Pest. Reg.	12,000	7/1/02 to 6/30/03	5	Sulfentrazone and flumioxazin in peas

PROJECT NUMBER: 3555-3375

TITLE: Organic Raspberry Production and Root Rot Control

PERSONNEL: Carol Miles, Chuhe Chen, and Peter R. Bristow, WSU Vancouver and Puyallup

REPORTING PERIOD: 2000-01

ACCOMPLISHMENTS:

RESULTS: In 2000, dairy manure was the only treatment to significantly increase yield. While *Trichoderma* and *Gliocladium* (both certified for organic production) produced fruit yields equal to the chemical standard (Ridomil), none of these treatments significantly outyielded the untreated check. Treatments had no effect on canes tied to the trellis to produce the crop in 2001. This was the case for both average cane length and the number of canes per plot. Berry yields in 2001 were comparable to those in 2000, but there were no significant differences between any of the treatments.

After two years, there is little evidence to show that the treatments have enhanced yield or impacted the number and size of canes. Three years are required to transition from conventional to organic production and it may take more than two years for organic methods to become established.

Table 1. Berry yield per plot (g),weight per berry (g) plus percent change relative to the untreated check for raspberry fruit harvested at WSU Vancouver REU in 2000 and 2001.

Year	Treatment	Berry yield (g)		% Increase	Berry Wt (g)		% Increase
2000	Dairy manure	3307	A*	32.9	1.90	A	9.8
	Ridomil	3012	AB	21.1	1.93	A	11.6
	G-41	2878	AB	15.7	1.86	A	7.5
	T-22	2819	AB	13.3	1.90	A	9.8
	Dairy manure + T-22	2619	B	5.3	1.91	A	10.4
	Gypsum	2618	B	5.2	1.81	A	4.6
	Untreated check	2488	B		1.73	A	
2001	Dairy manure	2794	A	-4.8	3.06	A	28.6
	Ridomil	4107	A	40.0	3.10	A	30.3
	G-41	3944	A	34.4	3.75	A	57.6
	T-22	3544	A	20.8	2.87	A	20.6
	Dairy manure + T-22	2722	A	-7.3	2.60	A	9.2
	Gypsum	3627	A	23.6	2.75	A	15.6
	Untreated check	2934	A		2.38	A	

* Treatments with different letters are significant at p=0.05 level by Tukey's multiple range test.

Table 2. Average cane height (inches), primocane number and percent increase relative to the control of raspberry plants at WSU Vancouver REU in 2001.

Treatment	Avg. Cane Ht. (In)		% Increase	Primocane No.		% Increase
Dairy manure	78	A*	-3.7	154	A	-6.7
Ridomil	80	A	-0.8	161	A	-2.4
G-41	80	A	0.0	171	A	3.6
T-22	77	A	-5.0	144	A	-12.7
Dairy manure + T-22	82	A	1.9	177	A	7.3
Gypsum	78	A	-3.4	156	A	-5.5
Untreated check	81	A		165	A	

* Treatments with different letters are significant at p=0.05 level by Tukey's multiple range test.

PUBLICATIONS: None at this time.

PROJECT NO: 3555-3375

TITLE: Organic Raspberry Production and Root Rot Control

YEAR INITIATED: 2000 CURRENT YEAR: 2001-2002 TERMINATING YEAR: 2003

PERSONNEL: Co-Principal Investigators

Carol Miles, Associate Agronomist and Extension Specialist, WSU Vancouver REU

Peter R. Bristow, Associate Plant Pathologist, WSU Puyallup REU

COOPERATORS:

Martin Nicholson, Ag and Research Operation Manager, WSU Vancouver REU

JUSTIFICATION:

Raspberries are produced on more than 12,000 acres in the Northwest U.S. and have a total farm gate value of $30-50 million annually. Although only a fraction of this acreage is grown organically, sales of organic food are increasing at a rate of 20% annually and Washington growers are interested in the potential of organic production. Some large- and small-scale berry growers are establishing organic production and according to these growers a major barrier to producing organic berries is pest management. Root rot is of primary concern and innovative and integrated organic pest management strategies are needed. These strategies will benefit all raspberry growers.

Dr.'s Peter Bristow and Carol Miles conducted a study in 1995-96 to test raised beds for raspberry root rot control in Southwest Washington. Dr.'s Bristow and Pinkerton continued and expanded this work in 1997 at WSU VREU to include raised beds, gypsum, and solarization. This work showed that raised beds or gypsum alone were not adequate to control raspberry root rot in the Pacific Northwest (Bristow, 1998 and 2000). In 1998-99, an organic grower in Nisqually, Washington working with Dr. Miles tested *Trichoderma*, a biological control organism, and manure for root rot control (Miles and Flores, 2000).

In 1999-00, with the support of the Organic Farming Research Foundation, the Washington Red Raspberry Commission, and the Washington State Commission for Pesticide Registration, this study was moved to WSU VREU, where the study was expanded to include *Gliocladium* (another biological control organism), gypsum, and manure. Both biological control organisms, *Trichoderma* and *Gliocladium*, are formulated, registered and sold as commercial pesticide products (T-22 and G-41, respectively), but neither is labeled for root rot control in raspberries. A conventional fungicide, Ridomil, is also included in the WSU VREU study for comparison of efficacy.

Study results at WSU VREU in 2000 indicated that *Trichoderma*, *Gliocladium*, and manure produced yields equivalent to yields produced with Ridomil, however manure plus *Trichoderma* resulted in depressed yields. In 2001, there were no significant differences in yield due to any of the treatments, however manure plus *Trichoderma* again resulted in the lowest yields. There appears to be a negative interaction between manure and *Trichoderma*, and the reasons for this are not understood. Results of this study will benefit growers who require effective organic or non-chemical strategies for root rot control.

OBJECTIVES:

- Analyze and compare performance of organic methods to control root rot at WSU Vancouver REU.
- Explore the effects of manure on the suppression of the root rot pathogen and impact on raspberry plant health and fruit yield.

PROCEDURES:

This study will be conducted within an eight-acre field of 'Meeker' established in 1997 at WSU Vancouver Research and Extension Unit (VREU), in a raised bed planting with drip irrigation. This site is ideally suited for the study due to its medium-to-high levels of root rot (*Phytophthora fragariae* var. *rubi*).

Organic methods to control root rot will be studied in a randomized complete block design with 4 replications and 8 treatments: *Trichoderma* (T-22), *Gliocladium* (G-41), gypsum, dairy manure, dairy manure inoculated with *Trichoderma*, solarization, Ridomil (chemical fungicide), and the control. Organic methods of root rot control will be compared to the conventional chemical fungicide (Ridomil) to provide all growers with a means to compare the efficacy of these options for disease management. Plots are small, 1 row wide and 25 feet long, and fruit will be hand harvested.

ANTICIPATED BENEFITS AND INFORMATION TRANFER:

The results from proposed studies will support the transition of berry production in the Northwest to organic and sustainable farming systems. It will provide all berry growers with sustainable IPM strategies that are cost effective and will reduce potential chemical exposure to consumers. This research will help the industry gain a competitive edge in the US and international berry markets with increased berry quality and reduced production costs. Each spring, Dr. Miles will compile results into a project report to be published in regional magazines and newsletters such as Western Fruit Grower, Washington Tilth Journal, and Pacific

Northwest Sustainable Agriculture Newsletter. Results will be available for the regional grower's and researcher's meetings and the field research site will be available for a field day. Updates and reports will be posted on the Agricultural Systems website, http://agsyst.wsu.edu, during the course of the study.

BUDGET:

- **Request for FY 2001-2002**

Time-Slip	$4,000
Employee Benefits (16%)	640
Operations (goods & services)	200
Travel[1]	160
Total	**$5,000**

[1]Travel is to and from research plots.

UNITED STATES DEPARTMENT OF AGRICULTURE
COOPERATIVE STATE RESEARCH, EDUCATION, AND EXTENSION SERVICE

OMB Approved 0524-0022

CURRENT AND PENDING SUPPORT

Instructions:

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

NAME (List PI/PD #1 first)	SUPPORTING AGENCY AND AGENCY NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
	Current:				
Carol A. Miles	WSCPR	$8,030.00	1/1/01-12/31/01	5%	Organic Raspberry
"	WSCPR	$8,000.00	1/1/01-12/31/01	5%	Organic Raspberry
"	USAID	$158,000.00	10/1/00-9/2/01	15%	Bean/Cowpea Collaborative Research Support Project
"	WSU IPM	$8,900	10/1/01 – 9/30/02	5%	Cover Crops in Organic Vegetables for Weed Management
"	WSU - DOE	$7,600	9/01/01 – 12/31/02	2%	Vegetable Weed Control and Irrigation Practices, and Riparian Zone Enhancement
"	USDA	$5,000.00	6/15/01-11/30/02	2%	Enhance Competitive Ag & Forest Prod.
	Pending:				
Carol A. Miles	American Bamboo Soc	$5,000.00	12/1/01-12/31/02	2%	Bamboo Variety Trials
"	Northwest Center for Small Fruits Research	$12,000	1/1/02 – 12/21/02	5%	Organic Raspberry Root Rot Control
"	WSU – Kellogg Foundation	$30,000	1/1/02 – 12/31/4	15%	Raspberry Integrated Management and Value-Added Processing
"	USDA	$60,000.00	6/15/02-11/30/03	10%	New Crops for Washington State

Project No.: New

Title: Gray mold fruit rot (*Botrytis cinerea*): field evaluation of new fungicides and timing of fungicide applications based on the stage of flower and berry development.

Year initiated: 2002 **Current year:** 2002 **Terminating year:** 2003

Personnel: Peter Bristow, Associate Plant Pathologist and
Gwen Windom, Agricultural. Research Technologist III
WSU-Puyallup Research and Extension Center

Justification: In both 1997 and 1998 red raspberry producers sustained unacceptable losses due to gray mold fruit rot. Berries rotted in the field before harvest and berries harvest for the fresh market turned moldy in containers before they could be sold. These losses occurred despite the use of fungicides registered at the time. In addition to weather conditions favorable to *B. cinerea,* widespread resistance to fungicides in the benzimidazole (Benlate) and dicarboximide (Ronilan and Rovral) groups contributed to rapid disease buildup. Beginning with the 1999 season, growers have been able to use the new fungicide Switch on annually granted Section 18 Emergency exemptions. Switch has two active ingredients, one acts systemically and the other as a protectant. Syngenta the manufacturer of Switch recently submitted its registration package for caneberries to EPA. Tomen Agro has also asked EPA to approve a request for its Botrytis fungicide Elevate. Both products are moving forward in the registration process but it is unlikely that either material will be fully registered before the 2003 crop season.

In the mean time it is important to continue to test promising materials and to find out how to best use Switch and Elevate along with currently registered fungicides in programs that a) control fruit and b) minimize the risk of fungicide resistance developing.

Recent research on strawberry in Florida has demonstrated that a single fungicide application to open flowers provided control equal to a three spray program that protected flowers from the time they opened (anthesis) through the ripening stage. This study and others suggest that in strawberry, infections that eventually lead to fruit rot occur when the flower is open. There is some evidence that bloom is also the critical time in red raspberry. If this is the case, then fungicide applications could be concentrated during bloom and applications to green and ripening berries might be reduced or eliminated. To test this idea, individual newly opened flowers need to be followed from the time a fungicide is applied until the berry is ripe.

Objectives:

1. Evaluate new fungicides (individually and in programs with other fungicides) for control of gray mold fruit rot under field conditions.
2. Determine when infections that eventually lead to fruit rot occur.
3. Determine what role different flower parts (sepals, stamens and petals) play in fruit rot.

Procedures: A field trial will be established in a commercial field with a history of fruit rot. Fungicides will be applied with an over-the-row boom sprayer. Treatments will be replicated four times and individual plots will be 25-30 feet long. Several newer fungicides will be tested individually or in programs with other fungicides. For comparison, the trial will also include a standard fungicide or program and an untreated or water check.

Newly opened flowers will be tagged so they can be followed until the berries are ripe. A fungicide will be applied to tagged flowers on the following schedules after flowers open (DAA = Days After Anthesis): a) untreated, b) 0 DAA, c) 3 DAA, d) 7 DAA, e) 14 DAA, f) 3+7 DAA, g) 3+7+14 DAA. Ripe berries will be picked as they ripen and recorded as either healthy (no rot), damaged (insects, etc) or moldy. Healthy berries will be incubated for 3 days in a moist chamber to assess rot developing after harvest. Starting just before and continuing through harvest, laterals will be collected twice weekly and every flower/berry categorized as to its stage of development. This information will be used to determine: a) the proportion of flower open on any given day during bloom and b) the time between fruit set and ripe berries (harvest).

Petals, sepals and stamens will be removed (individually and in various combination) from tagged flowers. Intact flowers will serve as the check treatment. Petals will be removed as soon is the flower opens. Sepals and stamens will be removed a few days later. As described above berries will be harvested as they ripen, categorized and healthy ones evaluated for rot in the post harvest test.

Anticipated Benefits and Information Transfer: We expect to be able to identify new fungicides and fungicide programs for control gray mold fruit rot. Efficacy data from this trial will help support registration requests to EPA by the manufacturer or through the IR-4 Program. Information from the time of infection portion of the project will aid in determining when to apply fungicides for optimum control. The results of this study will also be disseminated through local and regional publications including the Pacific Northwest Plant Disease Manage-

ment Handbook and the Pest Management Guide for Commercial Small Fruits when and where appropriate.

Budget:

Notes:

- WSU is no longer funding 100% of the salary for the Agricultural Research Technologist III position in my program. For this reason, a portion of that salary is included in this budget.
- Because of the financial constraints the Commission is working under this year the budget is broken down by objective.

Request for FY 2002-03

Category	Objective1 Fungicide trial	Objective 2 Infection timing	Objective 3 Flower parts
Salaries (Agr. Res. Tech.)	500	500	500
Timeslip labor	1900	1700	1000
Services and Supplies	500	200	200
Travel	900	300	100
Benefits			
Agr. Res. Tech.	130	130	130
Timeslip labor	115	105	60
	$4045	$2935	$1990
Grand total		**$8970**	

Other Support for the Project:

1) A grant-in-aid request will be submitted to each company with a fungicide in the trial.
2) One or more grant proposals will be submitted to the Washington State Pesticide Registration Commission (WSPRC) for funds to a) reimburse the cooperating grower for fruit that must be destroyed because it has been treated with experimental chemicals and b) support other project costs. The WSPRC requests matching support for projects it considers. This year the WSCPR received $150,000 of the "Federal Grant for Specialty Crops and Agricultural Promotion" to be used to provide full or partial matching funds for research projects submitted by "minor, minor crop" commodity groups such as the Washington Red Raspberry Commission. In-kind contributions (insect and weed control, harvesting, etc.) from the cooperating grower can also be used for the match.

Washington State University
(Grant Proposal)

PETER R. BRISTOW
(Name)

WASHINGTON RED RASPBERRY COMMISSION
(Granting Agency)

NOVEMBER 6, 2001
(Date)

13C-3761-5253 SURVEY OF PROPAGATION FIELDS
13C-3761-4251 SOURCE & RATE OF GYPSUM
NEW: GRAY MOLD FRUIT ROT: FIELD EVALUATION OF FUNGICIDES AND TIME OF INFECTION
(Proposal Title)

The grant proposal has included funds in the budget for safety equipment.

Peter R. Bristow
(Principle Investigator)

saftyfrm.dag

Executive Summary Sheet

Title: Insect and Mite Control in Red Raspberry

Personnel: Lynell K. Tanigoshi, Associate Entomologist
Jeanette R. Bergen, Agricultural Research Technologist
Todd A. Murray, IPM Coordinator, Whatcom County Extension

Project No: New

Project Duration: 2002-2004

Calendar: 2001

Proposed Budget: $4,640

Other Support:

Identification of Problem or Need: Even with the recent registration of Brigade, the arsenal of 12 recommended pesticides for red raspberry is at risk. Of these compounds, most of the usage is center on 2-3 insecticides-miticides. The regulatory or resistance selection loss of any of these key pesticides would leave the industry with no cost-effective alternatives/options for root weevils, spider mites and aphids.

Benefits: Effective and timely economic control of key and secondary insect and mite pests on red raspberry.

Economic Justification: The loss of diazinon or azinphos-methyl would result in a significant impact because there are no options for western raspberry fruit worm and raspberry crown borer. There are no effective options for root weevil and spider mite control in Washington.

Evaluation and Accountability: The researchers are responsible for evaluation and reporting of this project to the red raspberry industry and scientific community. Red Raspberry Commission is responsible for evaluating project's progress and making recommendations for future directions. Growers will assess usefulness and adaptability of results to their respective programs.

Project No.: New

Title: Insect and Mite Control in Red Raspberry

Year Initiated: 2002 **Current Year:** 2001 **Terminating Year:** 2004

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

Justification: Federal passage of the USEPA's Food Quality Protection Act (FQPA) in August, 1996 has put continued registration of all neurotoxins such as the organophosphates, carbamates and even pyrethroids at great risk. Issues regarding older pesticides (e.g., chlorpyripyhos, diazinon, endosulfan, malathion) under EPA's rigorous risk assessment process are beginning to impact registrant decisions to no long support agricultural uses through cancellation and selective amendments to their product registrations. The manufacturers of diazinon have agreed to cancel all its indoor and lawn uses along with about 30 agricultural uses. A review of insecticides and miticides in EB1419, *Pest Management Guide for Commercial Small Fruits, 2001* for red raspberry lists only12 pesticides recommended for effective insect and mite control. Six of them are nerve poisons and three of them are "older" organophosphates. Two of the remaining are pyrethroids and one a carbamate. The loss of the six older pesticides would leave our paltry red raspberry arsenal with specific compounds which EPA euphemistically call, "reduced-risk pesticides" and "biorational." These are a microbial, *Bacillus thuringiensis* an IGR for caterpillar control, inorganics lime sulfur (eriophyid mites), cryolite bait (root weevils) and insecticidal soap (spider mites). The reduced risk characterisitcs for the aforementioned pesticides are important, most of them are not cheap and their minimal residual activity and selectivity may not make them especially cost and pest effective for our current red raspberry production. Moreover, 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.

Objective:

1. Evaluate traditional and biorational products such as insect growth regulators, neonicotinoids, novel compounds such as pymetrozine and microbially-derived compounds for the control of raspberry crown borer, raspberry aphid, root weevils and thrips.

2. Continue evaluating experimental acaricides for spider mite control and to rate their toxicity to the phytoseiid predator, *Neoseiulus fallacis.*

3. Evaluate the efficacy of synthetic raspberry crown borer pheromone and traps for efficiacy in monitoring populations.

4. Conduct preliminary trials on the efficacy of diazinon alternatives such as the neonicotinoids and pyrethroids to control prebloom/white bud stage populations of the western raspberry fruitworm, *Byturus unicolor.*

5. Evaluate a range of colored, UV reflective sticky traps, to monitor adult raspberry beetle activity during the prebloom stage to optimize spray application(s).

Procedures:

1. Pending their seasonal abundance, the multiple pest species listed for laboratory bioassays will involve modifications of our standard Petri dish bioassay and foliage treatment applied in aqueous suspension with a Precision Spray Tower. Mortality through contact and stomach modes of entry will be assessed after 24 and 48 hours. Field trials will be applied with a tractor mounted six tank plot sprayer equipped with an over the row boom for which nozzle configurations can be altered and modified (e.g., drench, basal placements). Posttreatment evaluation for root weevils will consist of plant shaken samples taken in late evening with our standard drop cloth placed on either side of the plot row. The standard beat tray, white side up, will be used to assess relative abundance of raspberry aphids and flower thrips. Larval raspberry fruit worm evaluation of a fall or spring drench application will consist of October visual examination of crowns for frass and canes that exhibit galls on cane bases. There is no certainty populations of raspberry root borer will be found in abundant densities given our current pest management program in commercial settings.

2. Twospotted, yellow and McDaniel spider mite species and phytoseiid predators will be field collected from several different red raspberry growing areas in Washington. One inch diameter raspberry leaf discs will be placed on saturated cotton wool in standard Petri dishes. For each acaricide, four disc replicates will be treated with concentrations equivalent to full, half and one quarter of the recommended field rate. The acaricides will be applied in aqueous suspension using a Precision Spray Tower applied to spider mites and predators on the leaf discs. Discs were provisioned with spider mites as food for the predatory mites. Both spider mites and predators were examined for mortality after 24 and 48 hours.

3. Pending their seasonal abundance, western raspberry fruit worm adults will be field collected in early spring and maintained in the laboratory on floricane foliage tips. Young leaves or new opened buds will be dipped in aqueous suspension at concentrations equivalent to full, half and one quarter of the recommended field rate when applied in 100 gallons of water per acre. The trifoliate leaves will be air dried then placed in individual Petri dishes. Several adult fruitworms will be placed in each Petri dish and examined for mortality after 24 and 48 hours. The experimental insecticide imidacloprid (Provado), bifenthrin (Brigade) will be compared with diazinon and a water-only control. Additional experimental compounds may be evaluated as determined appropriate.

4. Variously colored sticky traps will be evaluated in the field to determine which color is the most effective in monitoring adults western raspberry fruitworm. Recent work in Switzerland and Scotland showed white, non-UV reflective sticky traps were trapping the European raspberry beetle.

5. This research will depend on the current status of research attempts to identify the chemical components of the female-based raspberry crown borer sex pheromone. Past research indicate that the active component of the raspberry crown borer sex pheromone, unlike other commercially available borer pheromones, is not an effective male attractant alone.

Anticipated Benefits and Information Transfer:

Expanding our knowledge about the basic biology of the root weevil complex in Washington state will provide growers and fieldmen with species specific parameters. This understanding will help them make better chemical applications decisions before the respective weevil or complex has begun to lay their eggs in the soil and on foliage. Further knowledge about selective tolerances by different

weevil species to current weevil recommendations will result in increased efficiency and productivity. Registration of additional insecticides with different modes of action and their use in a pesticide rotation program will prolong the development of spider mite resistance or potential for their posttreatment flare-up. Pending registrations of additional insecticides and miticides with different modes of action (e.g., neonicotinoids, carbazate, pryridine compounds), a weevil and spider mite control program that integrates biological control for spider mite control in red raspberry may be realized. Research must refine monitoring tools and identify compatible/selective chemical controls for secondary pests such as the western raspberry fruitworm, aphids and raspberry crown borer. 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:

		2002
01	Salaries	$4,000
07	Employee benefits (16% of 01)	640
Total		**$4,640**

We would like this grant to be submitted to the Washington State Commission on Pesticide Registration and to ask for a split of $4,640 for Washington State Red Raspberry Commission and $15, 640 for the Washington State Commission on Pesticide Registration. Donations of land and crops by the Vancouver Research Unit and growers can be used as a match.