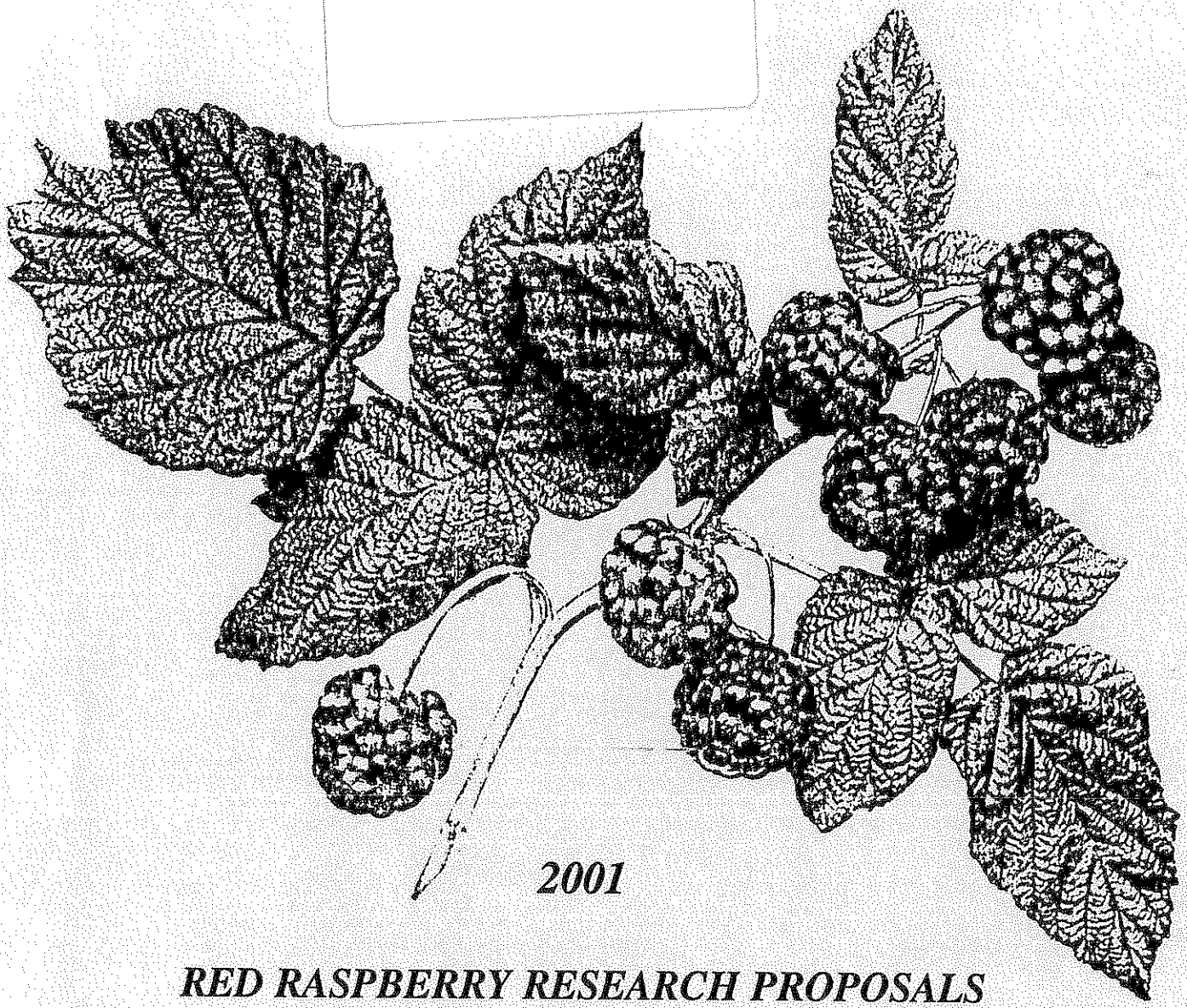

2001

RED RASPBERRY RESEARCH PROPOSALS

2000 PROGRESS REPORTS

to the

WASHINGTON STATE RED RASPBERRY COMMISSION

and

NORTHWEST RED RASPBERRY GROWERS ASSOCIATION

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2000-2001

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A:RaspComm.01/cp3/cm
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Summary
Budget Requests

On-Going Projects

Project No.	Short Title	Lead Scientist	Amount Requested
13C-3755-5641	Raspberry Breeding	Moore	$ 38,000
13C-3755-7641	Advanced Testing/Vancouver	Moore	7,000
13C-3755-8641	Advanced Testing/Mt. Vernon	Moore	6,000
13J-3543-4977	Orange Tortrix Control	Tanigoshi	4,480
13C-3555-5784	Yield Efficiency	Klauer	11,100
	Bushy Dwarf Resistance	Martin	12,000
	Cultivar Development for PNW	Kempler	7,000
13C-3761-5253	Phytophthora root rot Survey	Bristow	5,470
13C-3543-5272	Studies:Biology/Phenology/Control	Tanigoshi	4,640
13C-3755-5967	Integrated Research	Tanigoshi	19,077
13C-3419-8228	Caneburning	Miller	13,600
13C-3543-3272	Clay Colored Weevil Control	Tanigoshi	2,660

New Projects

Short Title	Lead Scientist	Amount Requested
Soil solarization	Bristow	$ 3,882
Rates/Sources of Gypsum	Bristow	7,110
Tomato Ringspot Virus	Martin	5,300
Evaluating Root Rot	Klauer	10,507
Integrated Organic Rasp.Prod.	Chen	15,600
Deer Fencing	Moore	7,100
Optimizing nitrogen	Klauer	8,580

A:Raspbk.01/cp3/cm

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: 2000

Accomplishments: In 2000, 61 crosses were made for cultivar development. Open pollinated seed was collected from 34 species hybrids. Almost 7,000 seedlings were planted at Puyallup from 1999 crosses. Selections will be made among these seedlings in 2002 and 2003. A new replicated planting was established of 186 plots with 49 clones (38 WSU clones) on raised beds treated with gypsum and Ridomil. Forty-two selections were made from seedlings planted in 1997 and 1998. There were 25 selections made in 2000 in the 1997 seedling planting in addition to the 33 selections made among the same seedlings in 1999. Qualicum was the best parent in this planting. There were 17 selections made in the 1998 seedling planting, with WSU 1112, WSU 1098 and Nootka being the best parents.

The 1997 replicated planting was harvested for the second time in 2000 (Table 1). WSU 1090, WSU 1024, WSU 1068 and then Meeker had the highest yields in 2000. WSU 1161, WSU 1024, WSU 1097 and WSU 1090 had the highest two-year total yield. WSU 1090 had the largest fruit in both 1999 and 2000. WSU 1161 had a short harvest season and very erect growth forming a very narrow row. WSU 1161 was selected from the cross of Brandywine and Chilliwack. Therefore it is ¼ black raspberry. Fruit was frozen for evaluation.

The 1998 replicated planting was severely damaged by deer browsing. One hundred sixty-five out of 207 plots (80%) had some browse damage. The damage was removal of the primary bud from the mid-portion of the cane in March or April. Thirty-nine percent of the buds did not break, with 28% not breaking because of browse damage and 11% from other causes. Because of the extensive damage, observations were made in the planting, but no harvest data was collected. Deer protection in the future is essential.

Machine harvest of advanced selections were observed by Jeremy Lott, WSU Lynden Satellite Facility, at a grower's field in Lynden (Table 2). Evaluations were made of the harvested fruit quality. WSU 1090, WSU 1097 and Nootka had the best harvested fruit quality.

Plants were propagated, planted in pots, grown outside and will be challenged for raspberry bushy dwarf virus resistance (RBDV). One third of the plants are known to be infected with RBDV and will serve as a source of the virus. Five hundred fifteen plants have been potted and will be tested to determine resistance/susceptibility to RBDV.

Presentations:

January, 2000. Strawberry and Raspberry fruit display. Northwest Food Processors, Portland, OR.

July 2000. Raspberry Field Day, Puyallup, WA.

July 2000. Raspberry Field Day, Mt. Vernon, WA

September 2000. Vancouver Field Day, Vancouver, WA

Table 1. 1999-2000 harvest of 1997 planted raspberries, Puyallup, WA.

Clone	Yield (t/a) 2000	Yield (t/a) 1999	Yield (t/a) Total	Fruit rot (%) 2000	Fruit rot (%) 1999	Fruit weight (g) 2000	Fruit weight (g) 1999	Fruit firmness (g) 2000	Fruit firmness (g) 1999	Harvest season 5%	Harvest season 50%	Harvest season 95%	Length of season
Clones present in 3 plots													
WSU 1161	7.8 a-d	8.7 a	16.6 a	1.5 b-e	6.6 c-e	3.56 d-f	3.88 bc	136 f-h	167 f-i	7/3 d-f	7/12 cd	7/27 g-i	24 g-j
WSU 1024	9.7 ab	6.1 a-d	15.9 ab	0.9 c-f	5.4 de	3.62 c-f	3.76 b-e	197 bc	214 bc	7/3 c-e	7/19 a	8/3 b-d	30 ab
WSU 1097	8.5 a-d	7.1 a-c	15.6 a-c	0.3 ef	2.3 e	3.43 e-g	2.94 f-h	122 g-i	106 l	6/30 g-j	7/12 cd	7/31 c-g	31 a
WSU 1090	10.2 a	5.3 b-e	15.6 a-c	0.9 c-f	21.4 a	4.93 a	4.71 a	207 ab	211 b-d	7/5 c	7/18 a	8/2 b-e	27 a-g
WSU 1068	9.2 a-c	5.8 a-e	15.0 a-d	0.9 c-f	6.0 de	4.16 b-d	3.79 b-d	165 d-f	193 c-f	6/28 ij	7/7 f-i	7/23 i-l	25 e-i
WSU 1099	8.0 a-d	7.0 a-c	15.0 a-d	0.5 d-f	2.9 e	3.63 c-f	3.94 bc	140 f-h	152 ij	7/3 c-e	7/16 ab	8/1 b-f	28 a-f
WSU 1067	8.7 a-d	6.1 a-e	14.8 a-d	1.7 b-d	9.7 cd	3.68 c-f	3.57 c-f	143 f-h	159 g-j	7/10 ab	7/18 a	8/4 ac	26 c-h
TULAMEEN	7.6 a-d	7.0 a-c	14.6 a-d	0.4 d-f	7.7 c-e	4.18 bc	4.27 ab	171 c-e	180 e-h	7/5 cd	7/17 a	8/5 ab	31 a
WSU 1098	6.4 c-e	8.1 ab	14.5 a-d	1.4 b-f	3.6 de	2.99 g	2.76 h	100 i	101 l	6/30 f-i	7/12 cd	7/25 h-k	25 d-i
MEEKER	8.8 a-d	5.0 c-e	13.8 a-e	1.0 c-f	3.6 de	2.92 g	3.32 c-h	212 ab	180 e-h	7/8 b	7/19 a	8/2 b-e	25 c-h
WSU 1162	8.3 a-d	5.4 b-e	13.7 a-e	1.8 b-d	6.2 c-e	3.58 c-f	3.16 e-h	126 g-i	112 l	6/29 h-j	7/11 c-f	7/26 hi	27 a-g
BC 89-33-84	8.0 a-d	5.6 b-e	13.6 a-e	1.1 c-f	5.5 de	3.86 c-e	3.62 c-e	228 a	241 a	6/30 g-j	7/12 cd	7/29 e-h	29 a-c
ORUS 1025-10	7.8 a-d	5.6 b-e	13.4 a-e	0.3 ef	3.6 de	3.92 c-e	4.26 ab	178 cd	179 e-h	7/11 a	7/20 a	8/7 a	27 a-g
WILLAMETTE	7.2 a-e	6.1 a-d	13.3 a-e	0.1 f	2.9 e	3.17 fg	3.33 c-h	164 d-f	184 d-g	7/1 e-g	7/12 cd	7/30 d-h	29 a-e
BC 90-4-48	8.0 a-d	4.8 c-e	12.8 a-e	0.2 ef	5.1 de	2.96 g	3.17 d-h	164 d-f	150 ij	7/1 e-g	7/13 bc	7/28 f-h	26 b-h
WSU 1193	7.8 a-d	5.0 c-e	12.8 a-e	0.6 d-f	5.4 de	3.45 e-g	3.41 c-g	198 bc	223 ab	6/29 g-j	7/10 c-g	7/28 f-h	29 a-d
WSU 1186	5.9 de	5.9 a-e	11.9 b-f	1.0 c-f	7.7 c-e	4.46 ab	4.30 ab	221 ab	226 ab	7/9 ab	7/19 a	8/4 ac	26 c-h
ORUS 870R-12	6.7 b-e	4.8 c-e	11.5 b-f	1.3 c-f	6.3 c-e	3.80 c-e	3.60 c-e	178 cd	209 b-d	6/29 h-j	7/8 e-i	7/21 kl	22 h-j
WSU 1183	6.0 c-e	5.3 b-e	11.3 b-f	2.7 ab	6.7 c-e	3.86 c-f	3.49 c-g	117 hi	120 kl	6/28 ij	7/5 i	7/19 l	21 ij
ORUS 1072-11	6.2 c-e	4.9 c-e	11.2 c-f	0.5 d-f	2.8 e	3.86 c-e	3.22 d-h	193 bc	205 b-e	6/29 h-j	7/9 d-h	7/26 h-j	26 b-h
WSU 1196	7.4 a-d	3.5 de	10.9 d-f	1.0 c-f	12.2 bc	3.64 c-f	3.52 c-f	141 f-h	154 h-j	6/30 f-i	7/12 c-e	7/27 g-i	26 b-h
WSU 1185	6.4 c-e	3.5 de	9.9 e-g	1.8 b-d	3.1 e	3.57 c-f	3.14 e-h	148 e-g	157 h-j	6/29 g-j	7/7 g-i	7/19 l	20 j
WSU 1082	6.8 b-e	3.0 e	9.8 e-g	2.2 a-c	16.6 ab	4.86 a	4.34 ab	179 cd	192 c-f	7/1 e-h	7/11 c-f	7/25 h-k	24 f-i
WSU 1184	6.7 b-e	3.0 e	9.7 e-g	1.5 b-e	4.4 de	2.89 g	2.88 gh	142 f-h	138 jk	6/30 f-i	7/11 c-f	7/25 h-k	25 d-i
WSU 1195	4.2 ef	3.7 de	7.9 fg	1.2 c-f	7.5 c-e	3.86 c-e	3.47 c-g	174 c-e	191 c-f	6/28 j	7/6 hi	7/20 l	22 h-j
WSU 1194	3.1 f	3.4 de	6.5 g	3.3 a	21.0 a	3.90 c-e	3.45 c-g	226 a	248 a	6/28 ij	7/8 f-i	7/21 j-l	23 g-j
Clones present in 2 plots													
ORUS 1149-1	9.4 a	7.8 a	17.2 a	1.0 ab	5.9 a	3.97 a	3.87 a	148 a	178 a	7/1 b	7/11 b	7/30 a	30 a
WSU 1190	10.8 a	6.4 ab	17.2 a	0.5 bc	2.9 a	3.21 bc	3.42 a	158 a	136 a	7/11 a	7/23 a	8/7 a	28 a
BC 90-4-48	8.3 a	4.8 bc	13.1 a	0.2 c	5.1 a	2.80 c	3.17 a	170 a	150 a	7/3 b	7/14 b	7/29 a	27 a
WSU 1200	7.9 a	4.1 c	12.0 a	1.2 a	7.9 a	3.70 ab	3.60 a	134 a	152 a	7/1 b	7/11 b	7/27 a	27 a

Values represent means of two or three 3 plant plots.
Means within columns followed by the same letter are not statistically different using Duncan's Multiple Range Test at P=0.05

Table 2. Evaluation of harvestability at Honcoop field.

	Mold and mushy fruit	Green	Volume
WSU 1024	2	2	3
WSU 1035	2	3	2
WSU 1068	1	2	1
WSU 1090	3	3	2
WSU 1097	3	3	3
WSU 1099	1	2	3
Nootka	3	3	2

Evaluated by Jeremy Lott, August 1, 2000. Scale: 4= best, 1=worst

PROJECT: 13C-3755-5641

TITLE: Red Raspberry Breeding, Genetics and Clone Evaluation

YEAR INITIATED:1996
CURRENT YEAR:2001
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. Each year new crosses will be made, new seedling plantings established, new selections made among previously established seedling plantings, and selections made in previous years evaluated.

1. Crosses will be made for summer fruiting cultivar development. 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.

2. Sixty-one crosses were made for cultivar development in 2000 and open pollinated seed was collected from 34 species hybrids. This seed will be sown in the greenhouse and when possible, 100 seedlings will be planted in the field for each cross. Selections will be made among these seedlings in 2003 and 2004.

3. Selections will be made among the seedlings planted in 1998 and 1999. 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.

4. Seedlings selected in 2000 (42 selections) will be propagated for testing in three replications of three hill plots and compared to standard cultivars. Because of the prevalence of root rot in the field and the subsequent difficulties in propagation by root cuttings, shoots of all selections will be collected and placed into tissue culture. Selections will be evaluated for yield, fruit size, fruit firmness, fruit rot, and harvest season as well as pest and disease resistance in 2003 and 2004. A fourth replication will be planted for subjective evaluations and use in pollinations.

5. Two plants of each selection will be placed into pots and exposed to RBDV. One RBDV positive plant will be included for every two test plants. The plants will be kept isolated from other raspberry plants and allowed to flower. Plants will be tested for virus each year and infection rate determined.

6. The replicated planting established in 1998 will be harvested for the first time in 2001.

7. Plants will be multiplied in tissue culture and propagated for testing at other locations and grower trials. WSU 1090, WSU 1112, WSU 1161 and WSU 1162 are currently being propagated by commercial propagators and may be available for grower trial in 2001.

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

9. WSU 1090 has been productive with large, firm fruit. Observations at

Lynden and WSU Vancouver indicate that it may machine harvest well. Morphological data to support the release of WSU 1090 will be collected in 2001.

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. Selected seedlings will be rapidly propagated and tested as rapidly as possible. Promising selections will be tested by commercial growers and release decisions made as rapidly as possible. Research results will be communicated at grower meetings, commission meetings, and field days.

PROPOSED BUDGET: Support is requested for a portion of the project operations budget at WSU Puyallup. Salaries for one WSU faculty member, two 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 0.30 of an Agricultural Research Technician I. The remaining 0.40 of the cost of the position will be funded for 2001-2002 by other commissions. A Lab. Tech. II will work 0.1 of the time with the raspberry breeding program. The remaining time, she will work with other programs. The remaining funds in the request will be used for timeslip labor for harvest, data collection, tissue culture supplies, greenhouse supplies, gypsum, fertilizer and other field supplies and travel to research plots and to grower meetings to present results of research.

Budget:	**2000-2001**	**2001-2002**
00 Salaries		
Agr. Res. Tech. 0.25 FTE	$8,133	
Agr. Res. Tech. 0.30 FTE		$9,665
Lab Tech 0.10 FTE	2,847	2,931
01 Timeslip Labor	12,500	12,500
03 Service and Supplies	4,989	5,521
04 Travel	500	500
07 Benefits		
Agr. Res. Tech.	3,172	3,595
Lab Tech	1,059	888
Timeslip	2,400	2,400
Total	**$35,600**	**$38,000**

Current & Pending Support

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

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
Moore, P.P.	**Current:** Oregon Raspberry and Blackberry Commission	$4,000	2000-2001		Development of new raspberry cultivars for the Pacific Northwest

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: 2000

Accomplishments:
In 1997, plants of several selections were available for grower trials. Some of these selections were planted and machine harvested at WSU Vancouver in unreplicated plots in 1999 and 2000 (Table 1). Root rot was not evident in this planting spring 2000, but many plants of some selections were dead by harvest time. The severity of symptoms was worse in rows lower on the hill and at the downhill end of the rows. WSU 1024 was planted in the lowest two rows and one row was killed and the other row severely damaged. WSU 1099 had the highest yields in both 1999 and 2000. WSU 1090 had yields above the mean in both years and the largest fruit both years. Harvested fruit of WSU 1090 had a good appearance.

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.

Publications:
Vancouver Field Day September 2000

Table 1. 1997-2000 machine harvest of 1997 planted raspberries
Vancouver, WA

Clone	Yield (kg/hill) 1999	2000	Total	Fruit weight (g)
WSU 1099	2.62	1.57	4.20	3.64
WSU 1066	2.42	1.53	3.94	3.36
WSU 1090	2.42	1.23	3.65	5.26
WSU 1082	1.65	1.72	3.36	5.10
WSU 1096	2.26	0.82	3.09	2.33
WSU 1024	2.37	0.59	2.96	2.31
WSU 1098	1.77	1.13	2.91	2.78
WSU 1067	1.75	0.24	1.99	2.74
Average	2.16	1.11	3.26	3.44

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; Stephen F. Klauer, Research Associate, WSU Vancouver.
YEAR INITIATED: 1996
CURRENT YEAR: 2001
TERMINATING YEAR: 2001

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 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 was established at WSU Vancouver in 1999. The clones included in this planting are selections that have performed well at WSU Puyallup, but have not been adequately tested at WSU Vancouver. Some clones that were planted in 1999 have been discarded and will not be harvested. Clones planned to be

harvested are WSU 1068, WSU 1090, WSU 1112, WSU 1145 and Kitsilano as well as standard cultivars. This planting will need to be maintained and the plants trained. It will be harvested for yield in 2001 and 2002.

2. A new replicated planting of raspberry clones for machine harvesting evaluation will be established in 2001. Selections to be included will be 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 will be 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 harvest costs and maintenance of raspberry plots at WSU Vancouver. This will include obtaining posts, wire, and herbicides. Travel would be to local grower meetings and to research plots.

Budget:	**2000-2001**	**2001-2002**
01 Timeslip Labor	4,750	4,750
03 Service and Supplies	1,340	1,340
04 Travel	150	150
07 Benefits	720	720
Total	**requested $7,000**	**$7,000**
	Funded at $4,000	

After consultation with the chair of the WRRC Research Committee and personnel at WSU Vancouver, $1,000 was transferred from WSU Vancouver funding for use at WSU Mt. Vernon in 2000-2001.

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: 2000

Accomplishments:
A planting of 12 clones was established at WSU Mt. Vernon in 2000. It will be maintained and harvested for the first time in 2002. 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 (Table 1). WSU 1090 had slightly lower yield than Meeker and was among the largest fruiting. In previous plantings at Puyallup, WSU 1090 had much higher yields in the second fruiting season. ORUS 2078y is a 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. Coho was harvested for the first time at WSU Mt. Vernon. It had good yield of attractive late season fruit, ripening slightly after Meeker and Tulameen.

Some WSU selections have been discarded since the planting was established. There are three WSU selections in this planting that are still being considered for possible release: WSU 1090, WSU 1024 and WSU 1068. Morphological data to support the release of WSU 1090 will be collected in 2001. Decisions on WSU 1024 and WSU 1068 will depend on evaluations by growers. Additional data should be collected on ORUS 2078y and Coho.

Publications:
Berry Field Day at WSU Mt. Vernon, July 20, 2000

Table 1. 1999-2000 harvest of 1997 planted raspberries, Puyallup, WA.

Clone	Yield (t/a) 2000	Yield (t/a) 1999	Yield (t/a) Total	Fruit rot (%) 2000	Fruit rot (%) 1999	Fruit weight (g) 2000	Fruit weight (g) 1999	Fruit firmness (g) 2000	Fruit firmness (g) 1999	Harvest season 5%	Harvest season 50%	Harvest season 95%	Length of season
Clones present in 3 plots													
WSU 1161	7.8 a-d	8.7 a	16.6 a	1.5 b-e	6.6 c-e	3.56 d-f	3.88 bc	136 f-h	167 f-i	7/3 d-f	7/12 cd	7/27 g-i	24 g-j
WSU 1024	9.7 ab	6.1 a-d	15.9 ab	0.9 c-f	5.4 de	3.62 c-f	3.76 b-e	197 bc	214 bc	7/3 c-e	7/19 a	8/3 b-d	30 ab
WSU 1097	8.5 a-d	7.1 a-c	15.6 a-c	0.3 ef	2.3 e	3.43 e-g	2.94 f-h	122 g-i	106 l	6/30 g-j	7/12 cd	7/31 c-g	31 a
WSU 1090	10.2 a	5.3 b-e	15.6 a-c	0.9 c-f	21.4 a	4.93 a	4.71 a	207 ab	211 b-d	7/5 c	7/18 a	8/2 b-e	27 a-g
WSU 1068	9.2 a-c	5.8 a-e	15.0 a-d	0.9 c-f	6.0 de	4.16 b-d	3.79 b-d	165 d-f	193 c-f	6/28 ij	7/7 f-i	7/23 i-l	25 e-i
WSU 1099	8.0 a-d	7.0 a-c	15.0 a-d	0.5 d-f	2.9 e	3.63 c-f	3.94 bc	140 f-h	152 ij	7/3 c-e	7/16 ab	8/1 b-f	28 a-f
WSU 1067	8.7 a-d	6.1 a-e	14.8 a-d	1.7 b-d	9.7 cd	3.68 c-f	3.57 c-f	143 f-h	159 g-j	7/10 ab	7/18 a	8/4 ac	26 c-h
TULAMEEN	7.6 a-d	7.0 a-c	14.6 a-d	0.4 d-f	7.7 c-e	4.18 bc	4.27 ab	171 c-e	180 e-h	7/5 cd	7/17 a	8/5 ab	31 a
WSU 1098	6.4 c-e	8.1 ab	14.5 a-d	1.4 b-f	3.6 de	2.99 g	2.76 h	100 i	101 l	6/30 f-i	7/12 cd	7/25 h-k	25 d-i
MEEKER	8.8 a-d	5.0 c-e	13.8 a-e	1.0 c-f	3.6 de	2.92 g	3.32 c-h	212 ab	180 e-h	7/6 b	7/19 a	8/2 b-e	25 c-h
WSU 1182	8.3 a-d	5.4 b-e	13.7 a-e	1.8 b-d	6.2 c-e	3.58 c-f	3.16 e-h	126 g-i	112 l	6/29 h-j	7/11 c-f	7/26 hi	27 a-g
BC 89-33-64	8.0 a-d	5.6 b-e	13.6 a-e	1.1 c-f	5.5 de	3.86 c-e	3.62 c-e	228 a	241 a	6/30 g-j	7/12 cd	7/29 e-h	29 a-c
ORUS 1025-10	7.8 a-d	5.6 b-e	13.4 a-e	0.3 ef	3.6 de	3.92 c-e	4.26 ab	178 cd	179 e-h	7/11 a	7/20 a	8/7 a	27 a-g
WILLAMETTE	7.2 a-e	6.1 a-d	13.3 a-e	0.1 f	2.9 e	3.17 fg	3.33 c-h	164 d-f	184 d-g	7/1 e-g	7/12 cd	7/30 d-h	29 a-e
BC 90-4-48	8.0 a-d	4.8 c-e	12.8 a-e	0.2 ef	5.1 de	2.96 g	3.17 d-h	164 d-f	150 ij	7/1 e-g	7/13 bc	7/28 f-h	26 b-h
WSU 1193	7.8 a-d	5.0 c-e	12.8 a-e	0.6 d-f	5.4 de	3.45 e-g	3.41 c-g	198 bc	223 ab	6/29 g-j	7/10 c-g	7/28 f-h	29 a-d
WSU 1186	5.9 de	5.9 a-e	11.9 b-f	1.0 c-f	7.7 c-e	4.46 ab	4.30 ab	221 ab	226 ab	7/9 ab	7/19 a	8/4 ac	26 c-h
ORUS 870R-12	6.7 b-e	4.8 c-e	11.5 b-f	1.3 c-f	6.3 c-e	3.80 c-e	3.60 c-e	178 cd	209 b-d	6/29 h-j	7/8 e-i	7/21 kl	22 h-j
WSU 1183	6.0 c-e	5.3 b-e	11.3 b-f	2.7 ab	6.7 c-e	3.68 c-f	3.49 c-g	117 hi	120 kl	6/28 ij	7/5 i	7/19 l	21 ij
ORUS 1072-11	6.2 c-e	4.9 c-e	11.2 c-f	0.5 d-f	2.8 e	3.86 c-e	3.22 d-h	193 bc	205 b-e	6/29 h-j	7/9 d-h	7/26 h-j	26 b-h
WSU 1196	7.4 a-d	3.5 de	10.9 d-f	1.0 c-f	12.2 bc	3.64 c-f	3.52 c-f	141 f-h	154 h-j	6/30 f-i	7/12 c-e	7/27 g-i	26 b-h
WSU 1185	6.4 c-e	3.5 de	9.9 e-g	1.8 b-d	3.1 e	3.57 c-f	3.14 e-h	148 e-g	157 h-j	6/29 g-j	7/7 g-i	7/19 l	20 j
WSU 1082	6.8 b-e	3.0 e	9.8 e-g	2.2 a-c	16.6 ab	4.86 a	4.34 ab	179 cd	192 c-f	7/1 e-h	7/11 c-f	7/25 h-k	24 f-i
WSU 1184	6.7 b-e	3.0 e	9.7 e-g	1.5 b-e	4.4 de	2.89 g	2.88 gh	142 f-h	138 jk	6/30 f-i	7/11 c-f	7/25 h-k	25 d-i
WSU 1195	4.2 ef	3.7 de	7.9 fg	1.2 c-f	7.5 c-e	3.86 c-e	3.47 c-g	174 c-e	191 c-f	6/28 j	7/6 hi	7/20 l	22 h-j
WSU 1194	3.1 f	3.4 de	6.5 g	3.3 a	21.0 a	3.90 c-e	3.45 c-g	226 a	248 a	6/28 ij	7/8 f-i	7/21 j-l	23 g-j
Clones present in 2 plots													
ORUS 1149-1	9.4 a	7.8 a	17.2 a	1.0 ab	5.9 a	3.97 a	3.87 a	148 a	178 a	7/1 b	7/11 b	7/30 a	30 a
WSU 1190	10.8 a	6.4 ab	17.2 a	0.5 bc	2.9 a	3.21 bc	3.42 a	158 a	136 a	7/11 a	7/23 a	8/7 a	28 a
BC 90-4-48	8.3 a	4.8 bc	13.1 a	0.2 c	5.1 a	2.80 c	3.17 a	170 a	150 a	7/3 b	7/14 b	7/29 a	27 a
WSU 1200	7.9 a	4.1 c	12.0 a	1.2 a	7.9 a	3.70 ab	3.60 a	134 a	152 a	7/1 b	7/11 b	7/27 a	27 a

Values represent means of two or three 3 plant plots.
Means within columns followed by the same letter are not statistically different using Duncan's Multiple Range Test at P=0.05

Table 2. 2000 harvest of 1998 planted raspberries, Mt. Vernon, WA.

Clone	Yield (t/a)	Fruit weight (g)	Fruit rot (%)	Harvest season 5%	50%	95%	Length of season
WSU 1099	13.2 a	4.2 d-g	2.6 a-d	7/6 cd	7/16 c	7/30 a-c	24 ab
Comox	12.5 a	4.2 d-f	6.0 a	7/5 d	7/17 c	7/30 a-c	25 a
WSU 1024	12.5 a	4.1 d-g	4.3 a-c	7/9 a-c	7/21 ab	7/31 a	22 a-c
Tulameen	11.4 a	5.4 ab	2.9 a-d	7/6 cd	7/17 bc	7/31 ab	25 a
WSU 1097	10.7 a	3.5 f-i	3.5 a-d	7/4 d	7/17 bc	7/29 a-d	25 a
WSU 1098	10.5 a	3.2 hi	1.9 b-d	7/6 cd	7/17 c	7/27 b-d	22 a-c
Coho*	10.4	3.8	3.2	7/9	7/20	7/30	21
WSU 1035	10.3 a	3.8 e-h	5.9 a	7/6 b-d	7/17 bc	7/30 a-c	24 a-c
ORUS 2078y	10.1 a	5.4 a	5.1 ab	7/11 a	7/23 a	8/1 a	21 bc
WSU 1068	10.1 a	4.5 c-e	4.1 a-d	6/29 e	7/8 d	7/20 e	21 a-c
Meeker	9.5 a	3.6 f-i	2.5 a-d	7/5 cd	7/17 c	7/29 a-c	24 ab
WSU 1090	8.2 a	5.4 a-c	3.7 a-d	7/6 cd	7/18 bc	7/29 a-d	23 a-c
BC-86-6-15	8.0 a	3.3 g-i	1.3 cd	6/30 e	7/10 d	7/20 e	20 bc
BC-89-33-84	7.9 a	4.1 d-g	0.6 d	6/30 e	7/10 d	7/22 e	22 a-c
WSU 1145	7.7 a	4.7 a-d	5.7 a	7/7 b-d	7/20 a-c	7/31 a	24 a-c
Qualicum	7.6 a	4.6 b-e	3.2 a-d	7/7 b-d	7/18 bc	7/27 cd	20 c
WSU 1067	7.4 a	3.8 e-h	5.3 ab	7/10 ab	7/17 c	7/26 d	16 d
Willamette	3.9 a	2.9 i	1.3 cd	7/4 d	7/10 d	7/18 e	15 d
Average	9.5	4.1	3.5	7/5	7/16	7/27	22

Values represent means of three 3 plant plots, except Coho which was only present in one plot.
Means within columns followed by the same letter are not statistically different using Duncan's Multiple Range Test at P=0.05

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: 2001
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.

1. A replicated planting of 18 raspberry clones was established at WSU Mt. Vernon in 1998. The clones included in this planting are selections that have performed well at WSU Puyallup, but have not been adequately tested at WSU Mt. Vernon. Because of root rot in previous plantings, the new planting was established on raised beds. This planting will need to be maintained and the plants trained. It was

harvested for yield in 2000 and additional data should be collected in 2001. WSU 1024, WSU 1068, WSU 1090, ORUS 2078y, Coho, Meeker, Qualicum, Tulameen, and Willamette will be harvested, the other 9 clones will not be harvested in 2001.

2. 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. This planting will need to be maintained in 2001.

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 and harvest of raspberry plots at WSU Mt. Vernon. This will include obtaining posts, wire, and herbicides.

Budget:	**2000-2001**	**2001-2002**
00 Salaries		
Agr. Res. Tech 0.10 FTE	$2,894	
Agr. Res. Tech 0.07 FTE		$2,107
01 Timeslip Labor	2,000	2,000
03 Service and Supplies	680	728
04 Travel	150	150
07 Benefits		
Agr. Res. Tech.	956	695
Timeslip	320	320
Total	**$7,000**	**$6,000**
	$5,000 funded	

After consultation with the chair of the WRRC Research Committee and personnel at WSU Vancouver, and additional $1,000 was transferred from WSU Vancouver funding for use at WSU Mt. Vernon in 2000-2001.

Project No.: 13J-3543-4977 (Extension)

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: 2000

Accomplishments:

1. Fourteen traps were placed in five red raspberry, 'Meeker' blocks, at the Vancouver REU from 10 August to 5 September. There were six green Intercept-BF traps and eight open white plastic buckets. The 3.5 quart white buckets were 6 inches in diameter and 8.5 inches deep. Orange tortrix (OT) pheromone and bifenthrin (Brigade) were placed on white plastic ties which were suspended level with the opening of four white buckets and the other four buckets were loaded with only OT pheromone. Three of the Intercept-BF traps were loaded with pheromone and bifenthrin applied on the bottom of the lure cage and another three traps were loaded with OT pheromone.

2. Field collected orange tortrix larvae were collected within their leaf shelters from thornless evergreen blackberry on Sauvie Island. They were separated from their shelter and placed on blackberry leaves while their shelters were individually treated with 1 ml formulated solutions from a Potter spray tower. Two experimental biopesticides tested were emamectin benzoate (Proclaim) and spinosad (Success) and the pyrethroids esfenvalerate (Asana) and bifenthrin (Brigade).

3. Knock-down activity to 3-4 day-old males were measured with the Touch and Kill technique. The pyrethroids permethrin, cypermethrin and bifenthrin at 6% conc. were formulated with Last Call, a UV-absorbing carrier containing 0.16% orange tortrix pheromone. Individual males were cooled in a refrigerator, then grasped with forceps and their tarsi/leg touched to the formulated droplet w/o attractant on a wood applicator for two seconds. The moths were placed in individual containers and held at room temperature. They were observed for 15 minutes for immediate symptoms of narcosis and mortality at 1 and 24 hours.

4. A single 2.2 acre block of evergreen blackberry was treated on 31 April with tebufenozide 2F (Confirm) at 16 oz/acre. A tractor pulled Rears hydraulic nozzle boom sprayer, equipped with a double row boom using 38 D4-45

TeeJet nozzles per row at 150 psi, delivering a minimum of 130 gal/acre at 3.1 mph. An adjacent 2.2 acre block was the untreated check. A second Confirm spray was applied on 14 June. This application is the traditionally applied one for OT cleanup prior to harvest.

5. Eleven Pherocon II traps and the OT pheromone lure were place in red raspberry fields throughout Clark and southwestern Cowlitz counties. These pheromone traps were monitor over twenty-four consecutive weeks.

Results:

1. A total of 195 adult males were trapped during the eighteen-day trial. Fifty-one percent were caught in the traps with pheromone and 49% in traps containing bifenthrin and pheromone. For the 40% that were caught in traps containing bifenthrin and pheromone, 4% were live and 96% were dead. For the 51% that were caught in the traps loaded only with OT pheromone, 89% were found live and 11% were dead. There was not statistical difference between the number of OT males trapped in buckets containing OT pheromone with or without bifenthrin.

2. These detailed lab bioassays (Table 1) underscored the need to monitor solitary feeding OT larval populations to time foliar application(s) before the summer generation larvae roll terminals and lateral leaf clusters into silken shelters. After 3 DAT, percent contact/stomach mortality was 87% for Brigade and Asana, while the biopesticides showed 47% and 67 mortality for Proclaim and Success respectively. These trials will be repeated next season along with direct topical applications.

3. These trials (Tables 2-3) indicated that the three pyrethroids were equally quick-acting nuerotoxins at 6% concentration when applied alone or in combination with Last Call 0.16% after 1 and 24 hours. Moreover, the moths were more susceptible to being knocked down and killed in the field from brief contact with the pyrethroids compared with malathion and diazinon.

4. On 5 July, both sides of rows in each large block were visually searched by several teams of summer employees for OT's conspicuous feeding-shelters. Total number of larval shelters for the Confirm block was 23 and 75 for the untreated check. The question remains whether a 70% reduction of OT larvae per 2.2 acres in late maturing blackberry will translate into economic control in red raspberry. Further research will focus on rate/application and timing for multiple treatments. The current label will allow growers to apply 64 fluid oz product per season at an application rate of 16 fluid oz/acre with a 14 day PHI. Hopefully we can continue Confirm trials next season with red raspberry on the Vancouver research and extension unit.

5. For the relatively mild spring and summer months of 2000, the averaged pheromone trap (Fig. 1) counts for the eleven traps/week clearly showed a nice relationship between the first and second generational flight of males. One can assume male flight counts to represent a marker for female emergence in fields with overwintering populations and timing for suppression of larval emergence during red raspberry harvest. Larval counts taken from 30 minute timed searches at each trap location showed a nice inverse relationship to male decline begin and through most of the harvest period.

Appendix

Table 1. Orange Tortrix Bioassay

Treatment	lb(AI)acre	% Mortality 1 DAT	2 DAT	3 DAT
Untreated check		0b	0b	0c
Brigade 10WP	0.1	53a	53a	87a
Proclaim 5SG	0.01	7b	40ab	47b
Success 2SC	0.09	0b	60a	67ab
Asana 2F	0.05	33ab	67a	87a

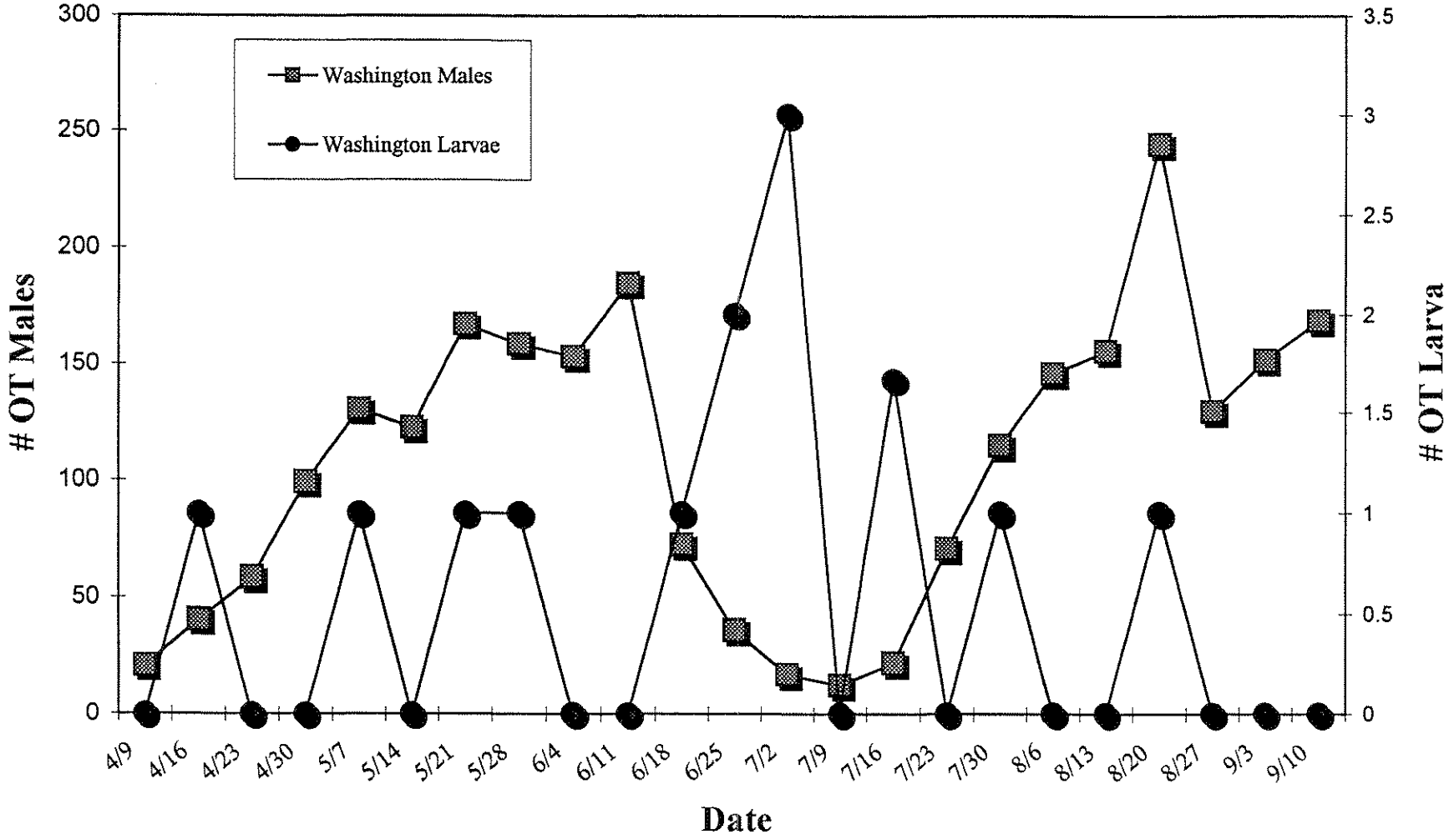
Percentages within columns followed by the same letter are not significantly different (Tukey HSD test, $P < 0.05$).

Table 2. Orange Tortrix Touch Test

Treatments	% Mortality Test #1 15 min	1 hr	24 hrs	Test #2 15 min	1 hr	24 hrs
LC 0.16% + Permethrin 6%	40	90	100	0	70	100
Permethrin 6%	50	60	90	70	100	100
LC 0.16% + Cypermethrin 6%	10	30	40	70	100	100
Cypermethrin 6%	10	40	100	20	90	100
LC 0.16% + Bifenthrin 6%	4	9	100	20	60	100
Bifenthrin 6%	0	50	100	0	90	100
Control (Last Call 0.16%)	0	0	0	0	0	0

Table 3. Orange Tortrix Touch Test

Treatment	% Mortality 15 min.	1 hr.	24 hrs.
Permethrin 6%	100	100	100
Cypermethrin 6%	90	90	100
Bifenthrin 6%	20	60	100
Malathion 6%	10	10	100
Diazinon 6%	20	20	100
Control (Last Call 0.16%)	10	10	20


Washington Males
Washington Larvae
OT Males
OT Larva
Date
300
250
200
150
100
50
0
3.5
3
2.5
2
1.5
1
0.5
0
4/9
4/16
4/23
4/30
5/7
5/14
5/21
5/28
6/4
6/11
6/18
6/25
7/2
7/9
7/16
7/23
7/30
8/6
8/13
8/20
8/27
9/3
9/10

Project No.: 13J-3543-4977 (Extension)

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

Year Initiated: 1998 **Current Year:** 2001 **Terminating Year:** 2001

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

Justification: The orange tortrix, *Argyrotaenia franciscana,* continues to be a key pest of red raspberries in southwestern Washington and Oregon. This leafroller species expresses two to three generations a year and most overwinter in a range of larval stages. Their larval instars web and feed on dead foliage, primocanes and fruiting buds. The traditional control strategy is a chemical program consisting of an adult prebloom spray in early May and a clean-up spray before harvest to control summer larvae feeding on new growth and forming rolled leaf shelters with silken strands. Insecticides registered for these two timing intervals include the organophosphates azinphos methyl (Guthion) and malathion, the carbamate carbaryl (Sevin) and *Bacillus thuringiensis* (Dipel, Javelin, MVP and others). Without the Section 18 for bifenthrin (Brigade), most growers have expressed dissatisfaction with the efficacy of the organosynthetics and timing is critical for Bts. Federal passage of the USEPA's Food Quality Protection Act (FQPA) in August, 1996 has put continued registration of all neurotoxins such as the OPs, carbamates and even pyrethroids at great risk.

However, over the past 3-4 years, the pesticide industry has experienced a "mini-Renaissance" in terms of the discovery of novel insecticides, otherwise known as biorationals and/or biopesticides. These insecticides have been shown to be very target specific, effective at low rates, selective, safe to bees, natural enemies, and thus safe to the environment and human health. Most are covered by EPA's *Reduced Risk Pesticide* and/or *OP alternative* status. Preliminary evaluations in cranberry with biorational insecticides (NJ, WA) indicated good potential for their integration within future biologically intensive pest management programs. These programs will include strategies such as: mating disruption, Attract and Kill (A+K) a new technique that kills and controls leafrollers using a mix of sex pheromone and a pyrethroid insecticide, and synthetic insect growth regulators (IGRs) that target sites regulating larval molt and growth and the conservation of

a complex of parasitoids identified in commercial fields of red raspberry in the Pacific Northwest.

Objectives:

1. Conduct large plot trials comparing conventional preharvest application with the newly registered molt accelerating compound, Confirm (tebufenozide), the A+K formulation (Last Call®) and the combination of Confirm and A+K for both larval and male OT control. Critical to the success of both biorational methods is to determine timing for the knock down of males before they mate with females (A+K) or targeting against larvae as they emerge from eggs and begin to feed within their rolled terminal leaf shelters.

2. Evaluate pheromone traps and/or standard degree day OT model as decision making indicators for aspects of orange tortrix field distribution, estimate of peak female/male emergence, with major egg hatch in June and spray recommendations (timing).

3. Conduct laboratory bioassays to continue assessing insecticide tolerances of several different populations of OT larvae to both experimental and registered insecticides.

Procedures:

1. Replicated field trials consisting of one acre sized plots will be conducted at an evergreen blackberry site in Cowlitz County and a potential blackberry site on Sauvie Island in Multnomah County, OR. Treatments will be full coverage sprays applied with a tractor-pulled Rears hydraulic nozzle boom sprayer, equipped with a double row boom using 38 D4-45 TeeJet nozzles per row at 150 psi, delivering a minimum of 130 gal/acre at 3.1 mph. The provisional timing for OT on red raspberry is 30 and 14 days preharvest for Confirm while our limited experience last season with A+K suggested application at about peak moth flight.

2. Pheromone traps will be in place by 1 April at similar localities used over the past two years (see progress report). Several HOBO® data loggers will be place at regional sites by 1 January. We will conduct weekly visual examinations of terminal foliage and beat tray sampling for early larval instar activity during bloom and preharvest. Degree-day accumulations will be update weekly and compared with pheromone trap data.

3. Laboratory reared and field collected OT larvae will provide us with timely numbers of even-aged larvae for which replicated treatments with experimental insecticides will be applied with a precision Potter spray tower. This method has provided important toxicological information about contact and stomach activity that is difficult under field conditions when the larvae have spun-up within their feeding shelters.

Anticipated Benefits and Information Transfer: To expand our biological knowledge about orange tortrix population dynamics, economic injury levels and dispersal behaviors will provide growers with additional inputs needed to make appropriate decisions for when, if necessary, to make properly timed application(s) of insecticides and bacterial insecticides.

Information from this applied research project will be used to support registration requests and funding to the IR-4 program and the Washington Pesticide Commission for Pesticide Registration. Because biorational biopesticides such as IGRs, microbial insecticides and fermentation-derived insecticides (e.g., spinosad, emamectin benzoate) are reduced risk and/or OP alternatives, a mechanism has been provided by USEPA to fast track them for federal registration. Results will be disseminated where appropriate at grower meetings, workshops and field days through the auspices of cooperative extension and WSU Vancouver REU's website.

Budget:

		2000
01	Temporary employee	$3,000
03	Supplies (field maintenance)	1,000
07	Employee benefits (16% of 01)	480
Total		**$4,480**

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 1998-2000 (continuation proposed)

ACCOMPLISHMENTS:

1998

- Yield components and actual yields quantified in the field for the split (ST) vs. the conventional trellis (CT) for 11, 14, 17, 18, 20 in. STs.
- Machine-picked actual yields quantified for an entire season for the first time for the ST vs CT.
- Minimum (17 in.) and maximum (20 in.) effective width of split trellis further clarified.
- Effect of split trellis on primocane growth further clarified.
- Environmental data collected in the field in order to study cultural phenology.

1999

- Littau Harvester suggested simple machine adjustments for the first time, that when correctly followed, resulted in a 19.4% increase in actual yield with tied-over canes for a 20 in. ST compared to the CT in Lynden, WA.
- The primary problems with machine harvest of the split trellis thus far, damage to laterals and premature harvest of green fruit were minimized to commercially acceptable levels.
- Rough cost analysis was completed and indicated significant profit advantage (net 15% more $/acre) for the split trellis if the approximately 20% yield advantage can be maintained.
- Environmental data collected in the field in order to study cultural phenology.
- New set of pruning timing trials initiated.

2000

- Two simple and quick machine adjustments tested for the first time last year were repeated at all sites this year and again resulted in significant yield increases (about 20%) for the ST.
- 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.
- Environmental data was collected in the field in order to study cultural phenology.

- Effects of delayed pruning on the following year's plant performance and yield were quantified.

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 23 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. Damage to laterals was minimized by spreading the picking heads early in the season, and then moving them closer every 3 harvests as laterals toughened. Premature pick of green fruit was

controlled by reducing beater speed until fruit quality was acceptable. In 2000, these adjustments were used for the first time in trials at WSUVREU, Burlington and Ridgefield, WA. Yields for the ST were significantly greater at all locations. Littau "over the row" harvesters with horizontal shaker heads and 50 inch throats were used in Burlington (1997 model) and at WSUVREU (1993 and 2000 models). ST (20 in.) yields were 23% greater after 11 harvests in Burlington, but finished at a 17.5% increase when the grower switched to a very narrow throated (33 in.) Littau 1985 machine which resulted in damage to the canopy. At WSUVREU yields were approximately 19.4% and 12.7% greater, respectively, for the 20 and 22 in. ST. The 22 in. ST sustained damage earlier in harvest and may be too wide for acceptable machine harvest. In 2000, harvest efficiency was quantified at WSUV REU and no differences between trellis types were found. For all treatments, efficiency was about 84% excluding fruit drop between harvests and 74% overall. This was typical of the two previous year's efficiency measurements. In Ridgefield, ST yields were 22% greater in a trial that was harvested with a Littau "siderow" machine with a 39 in. throat and horizontal shaking heads. This is very significant because it expands (by 129%) the number of Littau machines currently in use that can accommodate a split trellis. Yield increases of this magnitude (around 20%) will generally increase profits for growers by approximately 15% per acre after deducting increased costs attributed to the ST.

While these results are exciting, an important question that remains is whether yields of this magnitude are sustainable for the ST. Our current trials have only tested these machine adjustments and realized approximately 20% yields for one year. In addition, this was the first year 51 and 56 cm widths were tested at WSUVREU. Split widths from 43 to 51 cm (17-20 in) appear to be optimal for machine harvest of the ST. Repeating the Ridgefield trial is especially important because it more than doubles the number of Littau harvesters that can be used with ST. Littau Harvester (Stayton, OR) has approximately half of the market share of raspberry harvesters in the Pacific Northwest (Norman Johnson, Littau Harvester, personal communication). This work will potentially impact a large number of growers.

In addition, we have no long term data of pest dynamics (fungal, mite and insect), for ST at any width for reasons stated above. In one 51 cm trial we saw an increase in red spider mite in Lynden, WA towards the end of harvest. It is thought that the increased leaf area exposed to light in the ST might be attractive to spider mites (Lynell Tanigoshi, personal communication). The canopy's ecological balance may be altered by the change in architecture and microclimate created by the ST. The larger canopy may require an adjustment in pesticide application. There is still some question as to whether the ST creates conditions more favorable for *Botrytis* with increased foliar growth or inhibits the disease with increased air circulation. So far, in trials that are sprayed equally, we have seen no difference in *Botrytis* levels. Unsprayed trials are being evaluated for the first time this year.

Currently, three growers are considering putting in large acreages of ST, but would feel more comfortable with long term ST yield data. Many resources have been invested in this project thus far, and this has culminated in a trellis system that can return significant profits to growers based on our most recent results. The ratio of potential industry profit to research dollar invested, however, is very great. The next logical step is to confirm sustainability of this system over a period of years so that final technology transfer can be made to a large part of the industry.

We propose to continue to examine the current trials at WSUVREU, Ridgefield and Burlington for both yield sustainability and any detrimental changes in pest dynamics. We will conserve resources by reducing the amount of data collected, as canopy growth patterns, leaf physiology, light interception and harvest efficiency are well documented. Data collection emphasis will be on machine harvested yields, potential yield components, canopy damage and pest dynamics.

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 replicated plots of Meeker red raspberry, canes were removed following harvest in August and again after three month intervals. Floricanes were removed in August, November and February. Machine harvested yield, estimated yield, yield components, floricane dry weight partitioning and primocane growth were measured. While we found no statistically significant differences in treatments, values from dates 1 and 2 consistently trended lower than those from date 3. 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.

Phenology and Temperature. Correlating plant and pest phenology with environmental data is a long-term process that can eventually allow us to model much of raspberry's biology and insect/mite/pest interactions. While it takes quite a few years to collect enough climatological data to be a reliable model for plant or pest phenology, we are continuing to learn more about what data should be collected, how, and where. In 2000, we monitored relative humidity, soil and air temperatures within raspberry canopies under study throughout the season. Because there is so much environmental data collected from numerous sites, analysis is slow. We are attempting to take the limited data we have at this time and compare it with general growth patterns, life cycles, etc. A striking example of temperature/plant/yield interactions was apparent in southern WA this year. Basic research from our program and others has clearly demonstrated that raspberry is photosynthetically most productive at around 72F. Temperatures above this can begin to stress the plant. In addition, we have shown that demand on the plant from roots, primocanes and fruit peaks at about one week into harvest. Knowing this, it is not surprising that yields were greatly reduced on average this season in southern WA and northern OR when very high temperatures occurred during that first week of harvest. A bumper harvest in 1999 may also have led to more average yields in 2000 in areas less affected by the heat wave.

Radioisotope Labeling. This work has already generated valuable information with regard to resource allocation in red raspberry and would continue to do so, but it has not been funded in recent years.

Publications:

Klauer, S.F. Chen, C. and J. Scott Cameron. 2000. Harvester adjustments substantially increase fruit yield and quality for the split vs. conventional trellis system in red raspberry. HortScience. 35(3): 505

Klauer, S.F., Chen, C., and T. Peerbolt. 2000. Harvester adjustments increase yield by 20% in 'Meeker' red raspberry. Proceedings of the 2nd Annual Small Fruit Grower's Workshop, Vancouver, WA, pp. 35-40

Klauer, S.F., Chen C., Cameron, J.S. and T. Peerbolt. 1999. Impact of an open trellis on yield, canopy growth, light interception, and leaf physiology of red raspberry (*Rubus idaeus*). Proceedings of the Annual Conference of the Western Washington Horticultural Association, Seattle, Washington, pp. 87-91

Klauer, S.F., Chen C., Cameron, J.S., and T. Peerbolt. 1999. Advanced testing of the split trellis in red raspberry: canopy dynamics, leaf physiology and machine harvest studies. Proceedings of the 41st 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. 88-89

Klauer, S.F. and C. Chen. 1999. Advanced development of split trellis system for red raspberry: cultural management and machine harvest studies. Proceedings of Northwest Center for Small Fruits Research, Seventh Annual Conference, Boise, Idaho, pp. 26-27

Klauer, S.F., Chen, C. and J.S. Cameron. 1999. Latest advances in development of split trellis system for red raspberry: cultural management and machine harvest studies. Annual Conference of the USDA Northwest Center for Small Fruits Research Proceedings, p. 31-32.

Klauer, S.F., Cameron, J.S., and Chuhe Chen. 1999. Advanced development of split trellis system for red raspberry: cultural management and machine harvest studies. HortScience 34(3): 536

Klauer, S.F., Chen, C. and J.S. Cameron. 1998. Advanced development of split trellis system for red raspberry: cultural management and machine harvest studies. Annual Conference of the USDA Northwest Center for Small Fruits Research Proceedings, pp. 26-27.

Klauer, S.F., Cameron, J.S., and Chuhe Chen. 1998. Impact of an open trellis on canopy growth, light interception yield and leaf physiology of red raspberry (*Rubus idaeus*). HortScience. 33(3): 468.

Klauer, S.F., Cameron, J.S., and Chuhe Chen. 1997. Effects of the split trellis on growth and yield of red raspberry (*Rubus idaeus*). HortScience. 32: 536

PROJECT NO.: **Continuation proposed of 13C-3555-5784**

YEAR INITIATED: 1991
CURRENT YEAR: 2000-2001
TERMINATING YEAR: 2003

TITLE: **ACHIEVING GREATER YIELD EFFICIENCY FOR WASHINGTON RED RASPBERRY PRODUCTION**

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

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

JUSTIFICATION: Red raspberry researchers in the Pacific Northwest estimate crop yield potential to be 3-5X greater than average yields reported by industry. Our mechanically harvested canopy may account for the loss of 50% of our potential yield through harvester losses and poor light interception. Remaining yield potential is still likely to be 2-3 times greater than that which is actually harvested. Yield is a function of cane number, fruit number and fruit size, and yield efficiency relates to obtaining the greatest yield per unit of land area. While higher yielding varieties may increase yield efficiency, we are currently harvesting only a fraction of the yield potential of current cultivars. Plant breeders have little information on where they could make progress.

Price fluctuations, land and water issues and increasing production costs demonstrate that increasing yield per unit area is critical, and training and pruning are key elements. Our current training model is very inefficient and requires change. In order to increase yield efficiency, one must first understand the biology of the plant, the influence of the cultural environment, and be able to determine cost-effective approaches to improving productivity. The raspberry plant acts resource-limited because roots, shoots and fruit all demand resources simultaneously. We also know that raspberry leaves are inefficient in partitioning photosynthates and that even normal summer temperatures can place significant stress on the top of the plant during fruit development while the roots perform better with warmer soil temperatures. Thus, in conjunction with shading losses, there are many sources of lost yield, which could be recovered with modifications to cultural management and training. The purpose of this project is to model cultural biology of raspberry while developing cost effective strategies to increase the efficiency of production.

OBJECTIVES: **(All to be addressed in 2001)**

1. Characterize yield potential of the red raspberry plant in relation to cultural practices and cane management regime.
2. Study interplant\intraplant competition and its influence on cultural practices such as optimizing cane density, time of pruning and training systems.

3. Initiate and continue studies with cost effective approaches to recovering yield potential through new trellis design and cane management strategies.
4. Investigate the use of kaolin (white clay spray) for reduction of heat stress, improvement of photosynthesis and as a potential mite, insect and fungal pest deterrent.

PROCEDURES:

Kaolin (white clay) spray: Recently there has been resurgence in the study of hydrophobic particle films for suppression of mites, insects and plant diseases. In particular, very small particulate white clay (kaolin) is being applied as a spray to a number of different tree fruits, nuts and berries (including blackberry) and a number of other plants. This leaves a white coating on the surface of the plant that is thought to deter attachment of fungal spores, act as a barrier or irritant to insects and mites and repel water that might otherwise aid in the spread of disease innoculum. It has been shown to be very effective in this way in a number of plants. A side benefit to its use is that in most plants tested, heat stress is reduced, and photosynthesis is enhanced. This could be especially useful in raspberry, which is heat sensitive. It's quite possible that use of kaolin could have mitigated much of the damage done to raspberry by the heat wave that occurred early in the 2000 harvest season in southern WA. An unpublished study in blackberry showed that no difference was found in processed jelly made from blackberries sprayed with kaolin. While kaolin may not be useful in an IQF market, it could be very useful for juice market fruit. It could also potentially be used post harvest to control insect, mite or fungal pests and could be used as part of an organic pest control program. For these reasons, it would be worthwhile to do some preliminary tests with it in raspberry.

An initial study will be conducted in replicated plots of 'Meeker' red raspberry at WSUV REU. Plots will be sprayed with a commercially available water soluble formulation of the kaolin spray at the recommended rate using a backpack sprayer and compared to unsprayed plots. Reapplication will be made as needed if it rains during the evaluation period. Photosynthesis will be measured periodically with our portable gas exchange system. Water use efficiency, transpiration and other physiological parameters will be calculated from these measurements as an indicator of heat/water stress. Estimated yield will be compared. Preliminary observations of plants will be made for incidence of disease, mites and insects.

Date of Floricane Removal: We have re-established this study in our planting in Vancouver. This year, floricanes will again be removed in August, November and February. Yield component analysis will be used to determine whether the contribution of floricanes after harvest is sufficient to increase productivity and alter yield components. While results already suggest later removal may be better, this is likely a practice with a cumulative influence and we seek to quantify this effect so that labor issues and economic returns may be factored into a recommendation.

Split Trellis Training System: In the last two years, two simple machine adjustments made to Littau "over the row" and "siderow" harvesters with throats 39 in. or greater have

resulted in increased yields of approximately 20% for the split (ST) vs. the conventional trellis (CT). We have shown that yields of this magnitude will offset any increased costs attributed to the ST, returning a net profit of approximately 15% more $/acre. While we understand many aspects of the plant's performance/physiology within this system, two areas of research deserve further work, long term sustainability of yield and pest/disease dynamics. We have just learned how to increase yield using simple machine adjustments. This has now been tested successfully in several fields, but not in any one field for more than one year. While we think ST yields of this magnitude will be sustainable, it is important to test this over a period of time in the same location before recommendations for major production changes are made. It is especially important to retest the Ridgefield site where a 22% increase for the ST was obtained with a narrower 39 in. "siderow" machine. This is a very good large scale grower trial (over 3 acres of ST vs CT). With the ST we are making a dramatic change in the raspberry canopy. This change may result in changes in fungal, insect and mite dynamics over time. Last year, we saw minor differences in fruit rot and potential differences in mite populations for the first time between trellis types. For the first time, we compared ST and CT that were unsprayed with fruit rot fungicides. We propose to focus our efforts on these areas of research and scale back most of the horticultural measurements that have already been well documented. At WSUV REU and the Ridgefield trellis sites, yield, canopy damage and machine fine-tuning data will be collected. Some ST and CT rows will be left unsprayed with fruit rot fungicides, rot quantified, and predator and pest mite populations will be extensively monitored. We will continue to collect environmental data using HOBOs and compare these data with pest population dynamics. We will continue to collect environmental data using HOBOs and compare these data with pest population dynamics. Funding from this proposal supports the Ridgefield and WSUV REU trials, while satellite funding supports the Burlington trial.

Phenology and Temperature: Red raspberry leaves have a low photosynthetic maximum in the low 70'sF and a higher root temperature optimum around 80F. It is likely that growth and productivity is negatively influenced by warmer weather during critical periods of growth and fruit production. In order to better understand the development of the plant relative to temperature patterns, we will again measure temperatures inside the canopy and in the root zone of replicated plots in an established field of 'Meeker'. These temperatures will be recorded from late winter through late Fall using small, inexpensive temperature recorders capable of taking hourly readings and being left out in the field for extended periods of time. Temperature records downloaded to computer will be compared against periodic assessments of growth and physiology.

Radioactive Labeling Studies: Studies will use $^{14}CO_2$ as a radioactive tracer to determine where the products of photosynthesis go during different stages of seasonal growth. In particular, the role of root growth in competing with fruit for products of photosynthesis will be further characterized. This is particularly important in understanding the nature of below ground carbohydrate reserves in raspberry. We have demonstrated that senescing floricanes actually contribute carbohydrates for a significant period after harvest, thus we will continue to study this aspect of floricane biology and its impact on hardiness and

productivity. Studies will be done in our new lab suite at WSU Vancouver using a 6' walk-in radioisotope hood.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:
Benefits: Red raspberry growth and productivity are poorly understood, greatly reducing cultural efficiency, productivity and profitability. While new information on plant biology is promising, growers may still only harvest 20-50% of the plant's yield potential. Cost-effective approaches to increasing productivity are being developed. In particular, a machine-harvested trellis that recovers significant amounts of lost yield potential would be of great economic benefit with little additional investment. Alternative measures to reduce heat stress and control pests could enhance efficiency.
Information\Technology Transfer: This information will be disseminated at regional and national grower's meetings as well as through local, regional and national publications. We will continue to work with WSU Cooperative Extension personnel to develop additional plots for public demonstration.

BUDGET:

	Requested 2000
Temporary employees	$7,500
Supplies and services	1,000
Equipment	600
Travel	800
Benefits (16% of 01)	1,200
TOTAL	**$11,100**

OTHER SUPPORT OF PROJECT:
Part of the funds for the WSUV REU satellite station has been requested to fund the satellite trellis site. A proposal has been submitted to the NCSFR for the trellis work.

WE GRATEFULLY ACKNOWLEDGE THE SUPPORT OF GROWERS WHO HAVE SUPPORTED OUR ON-FARM EFFORTS, ESPECIALLY JERRY DOBBINS, SAKUMA BROS, GEORGE HOFFMAN, AND RANDY HONCOOP.

Project No.: 13C-3761-6718

Title: Integrated control of Phytophthora root rot.

Personnel: P. R. Bristow, Associate Plant Pathologist and G. E. Windom, Agricultural Research Technologist III, Washington State University, Puyallup Research and Extension Center, and C. A. Miles, Crop Specialist, WSU-Vancouver Research and Extension Unit

Reporting period: 2000 (Terminal report)

Accomplishments: 2000 was the second year of fruit production for this 1997 planting of 'Meeker' and 'Skeena'. The trial was design to look at the use of: 1) raised beds, 2) Ridomil treatment and 3) soil amended with a high rate of gypsum just before planting in an integrated program for controlling root rot caused by the soil borne fungus *Phytophthora fragariae* var. *rubi*. The highest yields for both cultivars were achieved when raised beds, soil amended with gypsum (at planting) and twice-yearly applications of Ridomil were used in combination. Each component in the integrated plan contributed to improving production. To date, the results for gypsum are extremely encouraging because plants are still benefiting from gypsum applied over two years ago. The decision was made to terminate this trial because differences were becoming smaller and there were few surviving plants in the untreated checks.

Results:

General. Treatments that promote primocane growth have more fruiting canes per plot the following year. Reducing damage from root rot delays the onset of fruiting cane senescence. In plots where disease control is poor, laterals often wither before berries ripen. In contrast, where the disease is controlled the leaves on fruiting lateral remain green well into fall (until the first frost). Horticulturists at WSU-Vancouver Research and Extension Unit demonstrated that leaves on fruiting cane laterals continue to contribute to the reserves of the plant after harvest. The most vigorous primocanes are produced in plots with good root rot control.

Raised beds. Each year the raised beds have settled and eroded reducing their original height of 12-13 inches by 3-4 inches. During the winter, tilled soil from the alleyways on either side of the beds was thrown up around the base of the plants to rebuild the beds. Annually, roots originating from the below ground portion of new primocanes grew into the added soil. Maintaining the height of

beds is critical to keeping soil moisture at a level that is unfavorable for activity of the fungus.

Soil moisture. From the outset, the planting has been irrigated with an overhead sprinkler system. Soil moisture data for 2000 confirmed data from previous years showing that soil in the raised beds remains drier than soil in flat beds at the same depths beneath the surface. Also, soil beneath the original soil line in raised beds was drier when compared to soil at the same depth in flat beds. Two factors may account for the soil being drier beneath the original soil line in raised beds. One, some of the water from rain and irrigation may run off the raised bed rather than percolate through soil in the bed. Two, the root system of plants on raised beds is considerably larger than that of plants on flat beds and a larger root system should absorb more water than a smaller one. The uptake of water by a larger root system maybe even greater if the roots are healthy.

Ridomil. The contribution of Ridomil to controlling the disease has decreased over time especially in flat beds where disease pressure is most likely higher. Even with reduced efficacy, Ridomil use represents a positive contribution when used with the other practices in the integrated plan.

Variety. While both Meeker and Skeena are susceptible to this root disease, Meeker has been less productive than Skeena in this planting. Skeena is a much heavier producer of primocanes hence there were more fruiting canes per plot the following year.

Presentations/Publications:

WSU-Mt. Vernon Raspberry/Blueberry Field Day, July 20 2000
WSU-Vancouver Field Day, September 21, 2000.

Appendix

Table 1. Impact of bed type, Ridomil and gypsum on the number of fruiting canes per plot by cultivar.

		Fruiting canes per plot, no.			
Cultivar	Bed type	None	Ridomil	Gypsum	Ridomil + Gypsum
Meeker	Flat	2.3	12.3	26.5	47.0
	Raised	44.5	36.5	50.5	69.8
Skeena	Flat	36.3	60.3	55.3	64.7
	Raised	72.7	81.3	60.0	88.0

[z] Plot = 24 feet of row (eight plants per plot at planting). 1999 primocanes thinned to a maximum of 12 per plant during the winter. Data collected 17 Mar 2000.

Table 2. Impact of bed type, Ridomil and gypsum on yield by cultivar.

		Yield, Kg per plot[z]			
Cultivar	Bed type	None	Ridomil	Gypsum	Ridomil + Gypsum
Meeker	Flat	0.006	0.637	1.104	1.418
	Raised	2.553	1.164	2.517	3.617
Skeena	Flat	3.146	4.378	6.220	6.812
	Raised	8.410	8.190	6.120	8.899

[z] Plot = 24 feet of row (eight plants per plot at planting). Plots harvested with a Littau rotary head harvester on 12 dates between 28 Jun and 28 Jul 2000.

Table 3. Impact of bed type, Ridomil and gypsum on the time of fruiting cane senescence by cultivar.

		Time of cane senescence rating[z]			
Cultivar	Bed type	None	Ridomil	Gypsum	Ridomil + Gypsum
Meeker	Flat	2.7	2.9	2.4	2.3
	Raised	1.9	2.7	2.7	2.3
Skeena	Flat	2.0	2.6	1.7	1.2
	Raised	1.7	1.3	1.6	1.1

[z].0-3 rating scale; where 3 = early death of laterals (before or during harvest) and 1 = late senescence (harvest completed before death occurred). Data collected 13 Sep 2000.

Table 4. Impact of bed type, Ridomil and gypsum on the number of new primocanes in 2000.

		Primocanes per plot, no.[z]			
Cultivar	Bed type	None	Ridomil	Gypsum	Ridomil + Gypsum
Meeker	Flat	4.4 c	10.0 c	15.4 c	39.5 b
	Raised	38.8 b	35.5 b	55.2 b	82.5 a
Skeena	Flat	84.3 a	98.7 a	143.0 a	144.7 a
	Raised	123.3 a	146.0 a	126.3 a	147.3 a

[z] Plot = 24 feet of row (eight plants per plot at planting)(no cane vigor control in the planting).
[y] Data from each cultivar were analyzed separately. Duncan's Multiple Range Test (P=5%).

Table 5. Impact of bed type, Ridomil and gypsum on primocane growth of Meeker and Skeena in 2000.

Comparison	Healthy primocanes per plot, no.		Wilted primocanes, %	
Meeker				
Flat bed vs.	16.5	***[z]	6.4	n.s.
Raised bed	52.3		7.8	
No Ridomil vs.	28.5	n.s.	6.8	n.s.
Ridomil[y]	41.9		7.6	
No Gypsum vs.	22.1	**	6.4	n.s.
Gypsum[x]	46.7		7.8	
Skeena				
Flat bed vs.	117.7	n.s.	2.2	n.s.
Raised bed	135.7		3.8	
No Ridomil vs.	119.3	n.s.	3.7	n.s.
Ridomil	134.2		2.3	
No Gypsum vs.	113.1	n.s.	3.7	n.s.
Gypsum	140.3		2.4	

[z] Level of significance: n.s.= non-significant, *=5%, **=1% and ***=0.1%.
[y] Applied to the soil immediately after planting and then each fall and spring thereafter.
[x] Mixed with soil before planting at the rate of 6 tons of agricultural gypsum per acre (broadcast).

Washington Red Raspberry Commission

Progress Report

Title: Engineering resistance to raspberry bushy dwarf virus

Personnel: Robert R. Martin, 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 & Helena Mathews, Agritope Inc., Beaverton, OR.

Reporting Period: 2000

Accomplishments and Results:

This year we grafted most of the transgenic lines of 'Meeker' red raspberry with RBDV infected material in June and again in October. After the second challenge in October the plants were retested by ELISA the first week of November. Out of 152 lines that were grafted twice, 91 were positive for RBDV, 3 had very low titers (about 1/10 that of the other plants) and 58 remained virus-free. Most constructs including the coat protein, nontranslatable RNA and two of the mutated movement proteins had about 2/3 of the grafted plants test positive for RBDV. However, the movement protein with the deletion of amino acids 2 – 6 gave mostly resistant plants. The plants that tested negative will be regrafted again in 2001 as well as the rest of the plants.

In the field there 34 of 243 lines that had darker green and larger leaves than wild type plants. Many of the plants seemed to grow out of this during the year. Harvey Hall from New Zealand suggested this was a carry over from tissue culture and he has seen it in raspberry plants in his test plots in the first year or two after planting materials from tissue culture. If this symptom of large dark leaves shows up in 2001,the plants will be taken out of the test. Most plants produced flowers this past spring and there was opportunity for field infection to start occurring. We will test each field plant for RBDV this spring.

Efforts to look at how many copies of the inserted gene is in individual transgenic lines has shown that anywhere from 1 – 5 copies of the gene has been inserted. We did this test on 5 lines for each of the different constructs.

'Meeker' plants have been transformed with the mutated movement protein of tobacco mosaic virus and these plants should be ready to put in the field this summer. The reason for using the mutated movement protein of TMV is that when tobacco plants were made with this construct they showed very good resistance to tobacco streak virus, which has many similarities at the molecular level to RBDV. With other work done with mutated movement proteins, there are always some plants that show resistance which is what we are seeing in these raspberries to date. Over the next few years we will get information on field resistance and fruit quality and yield.

Popular article: This work has appeared in the Agriculture Research publication which highlights research projects in the USDA-ARS. It is also being included in the quarterly report (fourth quarter) from the USDA-ARS to Congress. The article in the Ag Research publication can be found at www.ars.usda.gov/is/AR.

Current & Pending Support (Robert R. Martin)

Name	Supporting Agency	Total $	Dates	% of Time	Project Title
Current					
Martin & Mathews	WA Red Rasp Comm	12,000	2000	8	Resistance to RBDV
Martin & Mathews	BC Rasp Council	13,000 (CA)	2000	8	Resistance to RBDV
Martin & Mathews	OR Rasp &Blackberry	3,000	2000	5	Resistance to RBDV
Martin	Washington Wine Adv Board	14,000	2000	5	Grape virus survey
Martin & Mathews	SBIR	23,000	2000-01	8	Resistance to RBDV
Martin	USDA	80,000	99-2001	5	Transmission of RBDV
Martin	NWCSFR	5,700	2000	5	Virus Clean Up Program
Pinkerton & Martin	NWCSFR	9,928	2000	5	Management of TomRSV
Pinkerton & Martin	NABGA	2,000	2000	5	Management of TomRSV
Pinkerton & Martin	OR Rasp&Blackberry	5,300	2001	5	Management of TomRSV
Pinkerton & Martin	WA Red Rasp Comm	5,300	2001	5	Management of TomRSV
Martin & Mathews	BC Rasp Council	13,000(CA)	2001	8	Resistance to RBDV
Martin & Mathews	OR Rasp & Blackbery	4,000	2001	5	Resistance to RBDV
Martin	NWCSFR	8,736	2001	5	Virus Clean Up Program
Pinkerton & Martin	NWCSFR	10,550	2001	5	Management of TomRSV
Martin & Coyne	National Research Initiative	450,000	2002-05	10	Identification of virus resistance Genes in plants

Washington Red Raspberry Commission

Title: Engineering resistance to raspberry bushy dwarf virus

Year Initiated 1996 Current Year 2001 Terminating Year 2003

Personnel: Robert R. Martin, 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 & Helena Mathews, Agritope 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 is a cooperative project between our lab and Agritope Inc. to transfrom Meeker raspberry with genes to confer resistance to raspberry bushy dwarf virus (RBDV). Recent work with two plant viruses suggests that movement protein (protein that allows the virus to move from cell to cell in a plant) may be a better target for virus resistance that coat protein. Also, work done at Oregon State University has shown that nontranslatable RNA may be an excellent strategy for engineering virus resistance. Therefore we have cloned and sequenced the movement protein as well as designed mutants of this gene, a nontranslatable RNA and the coat protein gene of RBDV and inserted these genes into Meeker red raspberry.

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.

Objectives:

1. Develop regeneration protocol for several Meeker red raspberry (Accomplished at Agritope).
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 (started in 1997, most of effort in 1998, completed in 1999).
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 should be ready to go in the field in 2001. The mutations have been done and transformations are underway.

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

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. Once developed the regeneration and transformation strategies allows for the easy introduction of additional traits. This may be traits for insect, nematode, or fungal resistance or to add traits that enhance the fruit quality once suitable genes for these traits have been identified. The regeneration and transformation protocols have been used in the accompanying proposal on 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 2000	12,000
Request for 2001	12,000
Salaries	8,000
Supplies	2,000
Travel	2,000

As in the past this proposal will be submitted to the Oregon Raspberry and Blackberry Commission and the B.C. Raspberry Council for funding. In the past all three grower groups have participated in the funding of this project. Funds have been made available from the USDA-ARS Post Doctorate Program to support the work on pollen transmission of RBDV. See current funding listed below.

Progress Report

Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre
British Columbia Berry Breeding Program

PO Box 1000, 6947 #7 Hwy.
Agassiz, BC
Canada V0M 1A0
Tel: (604)796-2221 ext. 224 Fax:(604)796-0359

Web site: http://res2.agr.ca/parc-crapac/english/1agassiz/crop_science/kempler.htm

Title: Red Raspberry Cultivar Development for the Pacific Northwest

Reporting Period: 2000

Personnel: Chaim Kempler, kemplerc@em.agr.ca
Brian Harding, hardingb@em.agr.ca
Susan Gibson, gibsonsa@em.agr.ca

Collaborators: Hugh Daubeny (emeritus), hdaubney@telus.net

Funding: In 1999/2000 funds were received from the BC Raspberry Growers 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).

Objectives: The goal of the breeding program is to develop superior red raspberry selections stressing exceptional fruit quality which includes flavour, size, firmness, ease of harvest and rot resistance. The program stresses the development of raspberry selections that exhibit traits such as increased suitability for machine harvesting, dark fruit, winter hardiness and resistance to root rot, to divergent aphid biotypes, and to raspberry bushy dwarf virus (RBDV).

Progress: In 2000, approximately 1,300 new seedlings were planted. All were from previous crosses with at least one parent being resistant to RBDV. Sixty-five selections were made among the 1997 seedling planting and eighty-eight among the 1998 planting. Of these, 26 have been chosen for yield and observation trials and 10 will be used for breeding. All 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 selections will be tested for resistance to root rot and RBDV and used in future crosses.

During the 2000 harvest season the 1996, 1997 and 1998 plantings were evaluated. Data on yield, fruit traits and harvest season is presented for each planting year in tables 1 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 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. Selection 90–19-34, which is a first backcross from *R. strigosus* and tested in greenhouse trials as resistant to root rot, had a high yield of fruit that are well suited for the processing market. It will be released for grower trials where it can be evaluated for its resistance to root rot, RBDV, and suitability for machine harvesting.

In the 1997 planting 89-2-89 and 89-34-41, followed by 92-5-1 and 89-6-13 produced the highest yield. Selection 92-5-1 produced attractive fruit which is dark in colour and appears to be very suitable for processing. In the 1998 planting, 92-4-11 followed by 91-28-4 and 89-33-84 produced the highest yield. This was the first harvest for this planting, and therefor more data is required to assess them.

Notes on cultivars and potential new cultivars:

Qualicum (Glen Moy x Chilliwack)

Recommended for trials. Fruit is large, firm and 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. 47

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.

BC87-14-20 (Newburgh x Qualicum)

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, BC87-14-20 plants tested in greenhouse trails showed a very good resistance to root rot. In the research plots it was vigorous, moderately productive, and produces 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 up to 50 % 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 about one week earlier then Meeker and fruit that appears to be suitable for IQF. Plant growth is vigorous with 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)

Recommended for trials. It 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 very vigorous, with strong spineless canes and strong long upright laterals. It will not

machine harvest. It is susceptible 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. 48

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 most likely will machine harvest 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 susceptible 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 high yield of large firm fruit that has very pleasant flavour that can be compared with 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 large meaty fruit. It produces plenty of primocanes. It 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*. The fruit is large, firm and is well spaced on laterals. The plant has an upright habit.

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

Has mid-season production period with light fruit that is most suitable for the fresh market and 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 aphids biotype.

BC90-11-44 (Algonquin x Qualicum)

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

BC90-19-34 (Tulameen x BC86-62-3)

It is a hybrid from a cross of Tulameen and a *R. strigosus* selection collected from Lake George, Minn., in 1993 by Jim Luby. It has shown resistance to root rot in greenhouse trials. It is resistant to aphids, not excessively vigorous, fruit shape is round, colour is bright with a very pleasant wild flavour. It appears to be well suited for the fresh and processing market. This selection has been used in many crosses. It is interesting that a first generation cross with species material has the potential of becoming a variety.

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

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

Selections BC90-4-48, BC90-5-30, BC92-4-18 and BC92-9-39 that were identified as potential cultivars have been eliminated because they tested positive for RBDV. Selection BC86-6-15 has been eliminated because of its high susceptibility to root rot.

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 and harvest dates of raspberry cultivars harvested in 2000, 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	3.99	14.3	43.9	9.0	4.0	3.5	5-Jul	17-Jul	35	2.0
87-12-32	1	3.28	11.8	14.0	6.2	7.6	3.4	13-Jul	21-Jul	19	1.7
Tulameen	1	5.32	19.1	13.4	20.1	2.8	4.1	10-Jul	24-Jul	43	2.3
87-14-20	2	4.27	15.3	18.2	5.7	1.9	4.2	9-Jul	23-Jul	29	3.1
87-14-35	1	5.03	18.0	1.9	28.4	7.5	3.9	21-Jul	31-Jul	32	2.0
87-3-37	1	3.85	13.8	4.8	29.1	5.7	3.7	17-Jul	24-Jul	43	2.0
87-5-1	3	3.80	13.6	1.6	9.9	2.1	4.3	17-Jul	25-Jul	23	2.3
89-33-84	3	4.50	16.1	18.5	16.4	2.0	3.8	9-Jul	24-Jul	44	2.1
89-34-41	3	5.70	20.5	11.7	18.5	2.2	3.1	12-Jul	24-Jul	41	2.2
90-11-44	1	6.23	22.4	14.7	23.1	3.7	3.2	10-Jul	24-Jul	43	2.0
90-19-34	1	4.45	16.0	2.1	37.2	8.2	2.8	17-Jul	31-Jul	36	2.3
90-8-11	1	4.70	16.9	4.2	23.1	6.1	5.2	17-Jul	24-Jul	23	2.6
NZ8724Wd10	1	5.83	20.9	31.1	3.3	4.5	1.2	7-Jul	19-Jul	25	3.3
WSU 908	1	4.22	15.1	0.9	46.8	4.9	3.3	21-Jul	31-Jul	39	3.0
Chilliwack	3	2.99	10.7	23.6	4.9	3.4	3.1	11-Jul	21-Jul	25	2.5
Kitsilano	3	6.62	23.8	6.3	26.3	1.6	3.1	14-Jul	28-Jul	39	2.2
Malahat	3	3.69	13.2	47.3	6.5	1.6	4.2	5-Jul	18-Jul	33	2.9
Meeker	3	3.69	13.2	20.8	5.9	1.9	3.0	10-Jul	22-Jul	27	2.9
Qualicum	3	4.44	15.9	20.3	7.0	2.6	4.4	11-Jul	22-Jul	27	2.1
Tulameen	3	4.31	15.5	23.8	11.7	4.6	4.3	9-Jul	22-Jul	35	2.3
LSD 5%		**1.68**	**6.0**	**14.0**	**7.3**	**4.4**	**0.7**	**5**	**4**	**12**	**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 June 26 and July 7, 2000.
[y]Late Yield harvested between August 7th and September 5th, 2000.
[x]Harvest ease was rated on six harvest dates, 1=easy, 5=hard.

Table 1b. Yield, fruit weight and harvest dates of raspberry cultivars harvested in 2000, 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]
1997 Planting											
89-2-89	2	6.16	22.1	4.5	14.2	2.2	5.6	17-Jul	27-Jul	30	2.8
89-33-84	3	4.73	17.0	15.0	14.0	2.1	3.6	11-Jul	24-Jul	38	2.5
89-34-41	3	5.60	20.1	14.0	13.5	3.5	3.2	12-Jul	24-Jul	34	2.6
89-6-12	2	3.34	12.0	38.4	2.3	3.2	4.1	6-Jul	18-Jul	28	2.4
89-6-13	1	5.23	18.8	1.8	37.1	3.2	4.5	19-Jul	31-Jul	41	3.0
90-8-20	1	3.65	13.1	18.0	3.3	2.2	5.3	10-Jul	24-Jul	22	2.3
91-15-40	3	5.22	18.7	19.9	11.5	3.6	4.8	10-Jul	24-Jul	31	2.5
92-10-53	3	4.74	17.0	13.9	6.3	4.1	3.5	12-Jul	24-Jul	25	2.7
92-5-1	3	5.44	19.5	10.5	9.4	1.8	4.1	12-Jul	24-Jul	28	2.1
ORUS1025-10	1	4.17	15.0	4.6	13.2	1.0	5.0	17-Jul	27-Jul	36	3.5
ORUS1072-11	1	3.41	12.2	46.4	1.4	4.5	3.6	5-Jul	17-Jul	27	1.7
ORUS870R-12	1	3.65	13.1	68.8	1.3	2.1	4.2	5-Jul	13-Jul	23	2.0
WSU 1024	3	5.16	18.5	6.6	15.0	4.8	4.0	13-Jul	26-Jul	31	2.4
WSU 1068	3	4.63	16.6	42.8	2.9	5.2	4.1	6-Jul	19-Jul	28	2.8
Chilliwack	3	3.43	12.3	21.0	4.2	4.9	3.6	10-Jul	22-Jul	25	2.3
Coho	1	3.37	12.1	10.6	23.1	1.2	3.5	10-Jul	27-Jul	43	3.3
Kitsilano	1	3.57	12.8	30.6	0.5	0.4	4.2	7-Jul	21-Jul	28	2.3
Malahat	3	4.45	16.0	48.2	5.2	2.3	4.7	5-Jul	18-Jul	31	2.3
Meeker	3	4.22	15.1	14.6	7.7	1.2	3.5	12-Jul	24-Jul	31	2.7
Qualicum	3	3.72	13.3	23.3	4.2	2.8	4.7	10-Jul	21-Jul	25	2.1
Tulameen	3	4.86	17.4	15.9	17.6	3.9	4.8	10-Jul	24-Jul	43	2.2
1998 Planting											
89-33-84	3	4.67	16.8	19.0	16.2	2.0	3.5	9-Jul	24-Jul	40	2.2
90-6-2	1	3.44	12.3	31.5	27.5	6.2	4.0	5-Jul	24-Jul	55	4.4
91-17-10	2	3.92	14.1	10.4	21.5	1.8	3.4	13-Jul	26-Jul	40	2.3
91-17-11	2	3.51	12.6	9.4	32.1	1.6	3.4	12-Jul	31-Jul	45	2.6
91-28-4	3	4.78	17.2	7.3	16.0	2.7	3.2	13-Jul	25-Jul	31	1.4
92-10-53	3	4.43	15.9	7.2	17.1	2.9	3.2	13-Jul	26-Jul	31	2.5
92-20-17	3	2.80	10.0	43.9	3.7	1.4	3.1	6-Jul	18-Jul	28	2.4
92-4-11	3	5.85	21.0	22.4	17.6	2.8	4.4	7-Jul	24-Jul	41	3.0
92-4-49	3	4.71	16.9	35.1	7.4	1.7	4.1	5-Jul	21-Jul	32	2.5
92-6-17	3	4.46	16.0	19.9	8.9	3.7	3.7	9-Jul	24-Jul	31	2.0
92-6-41	3	4.81	17.3	11.6	14.0	3.6	2.9	12-Jul	24-Jul	28	1.9
92-7-43	2	3.38	12.1	18.2	22.9	2.5	3.1	10-Jul	26-Jul	43	2.4
92-9-15	1	4.47	16.0	59.6	2.1	1.5	4.0	5-Jul	17-Jul	27	2.8
92-9-33	3	1.98	7.1	48.9	4.8	3.7	4.3	5-Jul	17-Jul	34	2.2
92-9-57	3	2.90	10.4	61.4	3.0	2.6	4.1	3-Jul	13-Jul	31	2.3
93-2-7	1	2.54	9.1	50.0	2.3	0.3	3.0	5-Jul	17-Jul	27	1.7
Meeker	3	4.17	15.0	17.5	6.1	1.8	3.2	8-Jul	24-Jul	30	2.7
LSD 5%		**1.68**	**6.0**	**14.0**	**7.3**	**4.4**	**0.7**	**5**	**4**	**12**	**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 June 26 and July 7, 2000.
[y]Late Yield harvested between August 7th and September 5th, 2000.
[x]Harvest ease was rated on six harvest dates, 1=easy, 5=hard.

Table 1c. Yield, fruit weight and harvest dates of raspberry cultivars harvested in 2000, Abbotsford, BC. (Unreplicated)

Clone	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										
Algonquin	5.16	18.5	16.9	16.5	6.2	2.8	10-Jul	24-Jul	30	2.3
Chilcotin	2.87	10.3	12.2	30.3	6.5	3.2	13-Jul	27-Jul	40	2.5
Comox	5.01	18.0	13.5	10.8	2.4	4.0	13-Jul	24-Jul	27	2.5
Elida	3.31	11.9	46.4	6.1	3.7	3.6	5-Jul	17-Jul	27	2.0
Encore	3.80	13.6	2.2	16.6	18.8	5.0	24-Jul	31-Jul	22	2.3
Glen Ample	4.09	14.7	18.1	21.7	2.3	4.3	10-Jul	24-Jul	30	2.8
Glen Clova	3.78	13.6	34.2	3.5	2.8	3.4	7-Jul	21-Jul	25	2.7
Glen Magna	4.73	17.0	8.8	29.7	3.8	4.5	13-Jul	27-Jul	40	4.0
Glen Moy	3.87	13.9	53.1	8.5	1.2	4.5	5-Jul	17-Jul	35	3.0
Glen Prosen	4.24	15.2	17.5	22.5	1.2	3.8	7-Jul	24-Jul	46	2.3
Glen Rosa	3.80	13.6	23.8	6.2	2.9	2.8	10-Jul	21-Jul	22	2.5
Glen Shee	3.34	12.0	12.6	28.2	3.8	4.1	10-Jul	24-Jul	43	3.0
Haida	4.96	17.8	13.4	17.7	7.3	2.9	13-Jul	24-Jul	27	2.7
M. Gaia	2.93	10.5	38.6	10.3	1.0	3.6	5-Jul	21-Jul	35	2.3
Nootka	2.44	8.8	36.4	12.6	1.6	2.7	7-Jul	21-Jul	33	1.7
Prelude	2.89	10.4	96.6	1.2	6.9	3.5	28-Jun	5-Jul	20	2.0
Skeena	2.38	8.5	34.5	3.3	1.7	3.1	7-Jul	21-Jul	25	2.0
Sumner	3.90	14.0	7.9	43.0	18.1	3.1	13-Jul	31-Jul	51	4.0
Williamette	2.90	10.4	19.2	3.7	1.7	3.4	7-Jul	19-Jul	25	2.7

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.
[z]Early Yield harvested between June 26 and July 7, 2000.
[y]Late Yield harvested between August 7th and September 5th, 2000.
[x]Harvest ease was rated on six harvest dates, 1=easy, 5=hard.

Table 2. Fruit traits of raspberry cultivars harvested in 2000, Abbotsford, BC.

Clone	Fruit Rot After 48 Hours (%)			Firmness[z] (g/cm2)	Soluble Solids Concentration[y] (%)
	10-Jul	24-Jul	31-Jul		
87-14-20	14.06	42.2	45.3	170	10.1
89-2-89	-	37.5	45.3	247	9.6
89-33-84	7.8	45.3	37.5	247	10.7
89-34-41	14.6	62.5	56.3	222	10.7
89-6-12	15.6	39.6	45.3	214	9.7
89-6-13	-	12.0	48.4	-	-
92-4-11	-	37.5	41.3	-	-
90-6-2	-	65.6	34.4	248	7.8
91-15-40	25.4	65.6	53.8	172	10.7
91-24-12	-	51.9	15.6	167	10.8
92-10-53	-	54.7	10.8	172	9.5
92-20-113	-	63.5	68.8	143	12.2
91-28-4	-	45.5	9.4	158	12.9
92-4-49	-	66.0	45.4	206	10.3
92-5-1	-	52.1	35.9	156	9.1
92-6-17	-	68.7	78.8	247	9.6
92-6-41	-	87.5	45.3	217	10.8
92-9-15	-	63.4	68.8	211	11.4
92-9-33	-	-	-	206	10.4
92-9-39	-	81.3	48.4	211	9
92-9-57	-	66.0	59.4	167	11.1
NZ8724Wd10	7.9	45.8	-	137	10.1
WSU 1024	-	-	-	199	9.3
WSU 1068	35.9	8.3	61.7	168	9.3
Chilliwack	12.5	31.3	28.1	210	12.3
Elida	3.1	-	64.6	-	-
Kitsilano	-	28.3	48.4	227	9.1
Malahat	20.3	71.9	34.8	210	11.3
Meeker	26.6	70.3	49.6	129	11.1
Nootka	3.1	-	-	-	-
Qualicum	3.2	46.9	53.1	226	12.2
Tulameen	15.6	87.5	62.5	222	11.6
LSD 5%	9.4	9.4	9.4	60	1.4

Data 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 four harvests.
[y]Means of 10 fruit from 4 harvests.

Project No: New

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

Title: **Red Raspberry Cultivar Development**

Personnel: Chaim Kempler and Hugh Daubeny
Pacific Agri-Food Research Centre, Agriculture and Agri-Food Canada,
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Project Description:
The program focuses on the development of red raspberry selections stressing suitability for machine harvesting, dark fruit, winter hardiness and resistance to RBDV, root rot, and aphids. Of particular importance is the release of new cultivars to replace Meeker with those 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 is resistance to diseases and pests such as raspberry bushy dwarf virus (RBDV), root rot, fruit rot and raspberry mosaic virus (RMV).

The RMV complex is a limiting factor in raspberry production and can be simply controlled by resistance to the aphid vector. The Pacific Agri-Food Research Centre (PARC) program, as a primary screen, uses reaction to the aphid vector (*Amphorophora agathonica*) of the RMV in the seedling stage. All the cultivars that are released from this program are resistant to this common biotype. A resistance-breaking biotype of *A. agathonica* has been found in North America and this has complicated the screening procedure. There is a need to find genes that are resistant to the resistance-breaking aphid biotype, or to the virus itself. RBDV causes symptoms that adversely affect fruiting and growth in susceptible raspberry cultivars and selections. The combination of RBDV with RMV has been shown to be particularly detrimental to growth and fruiting. Breeding for resistant cultivars has controlled the common strain of the RBDV virus. Of cultivars released from the program in the past, Haida and Nootka are resistant to RBDV, while Chilcotin, although not known to be resistant, has never tested positive to RBDV and is likely to have very high tolerance.

The PARC breeding program is using selection of *R. strigosus* as new sources of resistance to the root rot caused by *Phytophthora fragariae*. First to third generation backcrosses are tested and used to incorporate resistance into cultivars and advance selections. BC90-19-34, a hybrid from such a cross, is root rot resistant and appears to be suited for mechanical harvesting and processing. It will be propagated and tested in grower trials.
Selections with improved fruit quality (size, firmness, and color) and with extended ripening dates will improve production and market appeal. Selections with fruit quality suitable for processing will benefit the value-added processing sector of the industry. Other important traits include

increased fruit number per lateral, reduced spines, 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 emphasized broadening the genetic base by using parents that were derived from a large variety of 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. Each potential cultivar that is now in grower trials has *R. occidentalis* in their derivation. Also, Kitsilano (BC 85-18-16) has *R. crataegifolius* in its derivation and BC 90-6-2 has the >Dalhousie Lake= selection of *R. strigosus* Maxim. in their derivation.

Objectives:

To develop red raspberry selections stressing suitability for the following traits:

- winter hardy plants that withstand low temperatures and desiccating winds throughout winter months, and/or have 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 high 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:

- harvesting of sound and rotted fruit, fruit firmness determinations with a pressure gauge, postharvest rot determinations, soluble solid and acidity determinations, evaluation of frozen samples
- observation of various pests and diseases under field conditions and screening seedlings for aphids and advance selections for root rot resistance
    - continued evaluation of all selections at the Abbotsford Sub-Station, including yield and fruit quality determinations, ease of harvest and reactions to various pests and diseases (i.e. fruit rot, cane disorders, aphids (which vector the mosaic virus complex), root rot (*P. fragariae)* and RBDV), and assessment of winter damage
    - advanced selections will be used in further breeding to develop a broad base of resistance

Activities:

- 2001 crossing blocks - continue backcross on the F1 to F3 rot root resistance selections, using RBDV resistant parents that have been received
- evaluation of seedling populations that were planted in 1998 and 1999
- establishment of advanced replicated trials to assess advanced selections suitable for processing and machine harvest
- evaluation of advanced selections in grower's 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 BC87-14-20, BC89-2-89, BC89-33-84, BC89-34-41, on large scale growers trials
- release BC90-8-11, BC90-8-20, BC90-11-44, BC90-19-34, BC92-5-1 for propagation to be included in PNW growers trails

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 BC87-14-20, 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 2001: $ 7000
The Washington State Red Raspberry Commission (WRRC) contribution could be matched by Agriculture and Agri-Food Canada Matching Investment Initiative (MII) fund with up to $ 7000.

Resource commitments:

Research assistance	$ 18,200
Summer students (5 x $7,500)	$ 37,500
Land preparation (fertiliser, 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)

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: 2000

Accomplishment: The actual field work on this project was begun in October 2000. Samples are being collected and sent to the WSDA laboratory in Prosser for testing. Recall, that sample collection was to occur late in the fall to allow root rot to develop as much as possible. However, sampling and testing will occur in time for additional samples to be collected in the vicinity of any plant testing positive for Phytophthora before digging begins. The goal is to collect 100 random samples per acre from 5 acres of nursery stock at each of the two cooperating nurseries (1,000 samples total from nursery stock. plantings). Each acre was divided into 100 sections (each section measured about 20 ft x 20 ft) and then one site was chosen at random from each section for sampling. Roots are dug at each sampling site and the position of the site logged with global positioning system equipment to facilitate resampling if necessary. Each sample is divided into two with one portion being frozen. The other portion is given code number and sent to the WSDA laboratory in Prosser for processing. In the laboratory, each root sample is ground and the extract assayed by an ELISA test specific for Phytophthora. The code number is a random number and does <u>not</u> identify the sample in any way.

If a sample tests positive, the specific site will be revisited to collect roots from plants around of the plant that originally tested positive. The corresponding frozen sample will be used to isolate the pathogen and/or sent to a laboratory in Canada where molecular techniques will be used to identify the species of Phytophthora in the roots. Again, only a code number will go with a sample.

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.

Project No.: 13C-3671-5253

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

Year Initiated: 2000 **Terminating Year:** 2005

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

Justification: In early October 1999, a meeting was held to review the rules and standards for the certification of caneberry plants. These rules and standards are part of the Washington Administrative Code. The 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 industry. The meeting was called because WSDA is about to update the rules and standards (last updated in 1992) and the concern of growers for improving the quality of planting stock. Currently, the detection of off-types, variety mixes, and detection of disease and insect pests is based solely on visual inspection of plants in propagation fields. Part of the discussion centered on including newer technologies for disease detection in the program. There is concern within the 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 the plant nurseries. After considerable discussion on this topic at the meeting the group decided that a pilot project to survey plant production field using ELISA technology for the detection infected plants was needed before including such changes in the rules and standards.

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.

Procedures:
Fields that were used for production of red raspberry nursery stock in 2000 and were part of the survey and are fumigated (according to rules in the certification scheme) and replanted for nursery stock production (short rotation) will be surveyed in fall 2001. Up to 2.5 acres per cooperating nursery will be surveyed. The procedures outlined here and used in 2000 will be used in 2001 unless there is a need for modification. Most of the acres included in the study will be planted in the spring with plants and roots being dug in the fall while some may be replanted using tissue culture propagated plants. It is anticipated that acres replanted on a long rotation (3-5 years) will be surveyed in later years.

One hundred root samples will be collected per acre (this corresponds to about 1 sample per box of 500 No. 1 plants). Each acre will be divided into 100 sections blocks based on how roots will be dug. A root sample will come from one randomly selected plant in each section. Using this technique, every plant in the acres surveyed has an equal chance of being selected for sampling. All sampling sites will be flagged and mapped using GPS equipment. Samples will be coded in the field and then sent to the WSDA laboratory for processing. An ELISA procedure that reacts with the pathogen will be used to detect infected plants. Sites with samples testing positive will be re-sampled plus additional samples will be taken from plants around the plant originally testing positive. Samples will be taken as close to the time digging as possible but early enough so that the results from any re-sampling will be known prior to the start of digging. In addition, plants flagged by WSDA inspectors will be sampled unless the reason flagging is known and not disease related. Lab results will be given to the respective cooperating nurseries so decisions on digging can be made if there are any positive samples. Two types of control samples will be included whenever samples are sent to the WSDA laboratory: 1) roots from known healthy plants and 2) roots from known infected plants. All samples will be coded so those handling and processing samples will not know from which farm, field or sampling site any given sample was collected.

Until the pilot project is completed: 1) the results from 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.

Budget:

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

*Lab fee for sample processing
**Rental of GPS equipment

Other support for the project:
None at this time.

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: 2000

Accomplishments: Resistance screening in the laboratory to several red raspberry breeding selections and *Rubus* spp. for black vine weevil resistance with feeding and egg laying bioassays were not conducted. Last summer was simply a 'poor' BVW season for collecting the numbers of weevils needed for replicated testing over three to four time intervals. This objective will be repeated next season. Three promising biorationale insecticides were tested in the laboratory at recommended field rates on the black vine, strawberry, rough strawberry and clay colored root weevil. We are pleased with their performance and hopefully can field trial them next year. Adequate numbers of seasonal black vine, clay colored, strawberry and rough strawberry roots weevils were collected to detail their ovipositional period, rate of egg production and total fecundity. This knowledge will provide pest managers with a better understanding of each species' egg potential and associated larval levels needed to make a well-timed preovipositional application(s). If adult weevils are controlled before egg laying begins in the field, the potential in-field increases from one season to the next should be reduced

Results: Though not significant, we observed differential responses by 4 root weevil species to bifenthrin (Brigade) and the experimental neonicotinoids in the Petri dish bioassays. Thiamethoxam (Actara) and acetamiprid (Assail) initial knock-down is not as rapid as Brigade, however, at 3 and 7 DAT there was no significant difference between both neonicotinoids compared with Brigade. The insect growth regulators diflubenzuron (Dimilin) and pyriproxyfen (Esteem) resulted in BVW laying infertile eggs. Dimilin is registered on cotton to control boll weevil through reproductive suppression (Tables 1-6). Figure 1 summarizes the reproductive trends for mature overwintering and summer-emerging black vine weevils, strawberry root weevil and clay colored weevil. Compared with last year's cumulative egg production data for overwintering and summer-emerging black vine weevils collected from Whatcom County, this year's weevil data from Clark County showed slightly earlier emergence and egg laying and higher cumulative egg production for overwintering black vine weevil. The average seasonal fecundity for the overwintering weevils was about 680 to 325 and for the summer-emergers about comparable at 210 to 225. Clay colored weevil fecundity for the past two years in the Northwood area was comparable at 25 to 30 eggs per weevil. The fecundity for a Clark County strawberry root weevil population averaged 375 eggs laid from late May to late August. These data for overwintering black vine weevil and strawberry root weevil

underscore the need for small fruit growers to monitor for these two species as they have to potential to lay many eggs before the traditional preharvest cleanup spray. When winter and early spring months are not as mild as they were this year, clay colored weevil will emerge around bud break, browse buds and initiate egg laying during their relatively short ovipositional period that is over by early June. Their feeding injury is irreparable and we've shown this species will incur economic yield losses very early in the growing season.

Appendix

Table 1. Black Vine Weevil Lab Bioassay

		% Mortality			
Treatment	lb(AI)/acre	1 DAT	2 DAT	3 DAT	7 DAT
Untreated check		26bc	26c	26b	26b
Actara 25WG	0.0625	94a	100a	100a	100a
Assail 70WP	0.15	34b	57b	80a	91a
Brigade 10WP	0.05	100a	100a	100a	100a
Brigade 10WP	0.10	100a	100a	100a	100a
Dimilin 25W	0.0625	9c	11c	11b	20b
Dimilin 25W	0.125	14bc	14c	17b	26b

Percentages within columns followed by the same letter are not significantly different (Tukey HSD test, $P < 0.05$).

Table 2. Rough Strawberry Root Weevil Lab Bioassay

		% Mortality			
Treatment	lb(AI)/acre	1 DAT	2 DAT	3 DAT	7 DAT
Untreated check		17c	20b	20b	29b
Actara 25WG	0.0625	77ab	77a	80a	91a
Assail 70WP	0.15	60ab	86a	91a	100a
Brigade 10WP	0.05	66ab	80a	83a	86a
Brigade 10WP	0.10	89a	91a	97a	100a
Dimilin 25W	0.0625	14c	23b	23b	26b
Dimilin 25W	0.125	49bc	91a	91a	91a

Percentages within columns followed by the same letter are not significantly different (Tukey HSD test, $P < 0.05$).

Table 3. Strawberry Root Weevil Lab Bioassay

Treatment	lb(AI)/acre	% Mortality			
		1 DAT	2 DAT	3 DAT	7 DAT
Untreated check		0b	0b	0b	10b
Actara 25WG	0.0625	81a	100a	100a	100a
Assail 70WP	0.15	95a	95a	100a	100a
Brigade 10WP	0.05	100a	100a	100a	100a
Brigade 10WP	0.10	100a	100a	100a	100a
Dimilin 25W	0.0625	0b	24b	24b	29bc
Dimilin 25W	0.125	14b	24b	38b	43c

Percentages within columns followed by the same letter are not significantly different (Tukey HSD test, $P < 0.05$).

Table 4. Clay Colored Weevil Lab Bioassay

Treatment	lb(AI)/acre	% Mortality			
		1 DAT	2 DAT	3 DAT	7 DAT
Check		0d	0c	0c	0c
Actara 25WG	0.0625	43bc	70ab	78ab	78ab
Assail 70WP	0.15	43bc	60ab	68ab	68ab
Brigade 10WP	0.05	78ab	90a	93a	98a
Brigade 10WP	0.10	90a	90a	100a	100a
Dimilin 25W	0.0625	3cd	3c	3c	3c
Dimilin 25W	0.125	45b	45b	45b	60b

Percentages within columns followed by the same letter are not significantly different (Tukey HSD test, $P < 0.05$).

Table 5. Black Vine Weevils Egg Bioassay

		% Hatch			
Treatment	lb(AI)/acre	1 DAT	2 DAT	3 DAT	7 DAT
Untreated check		82	100	100	100
Dimilin 25W	0.0625	75	14	0	14
Dimilin 25W	0.125		34	0	34

Table 6. Black Vine Weevil Eggs Bioassay

		% Hatch					
Treatment	Rate	1 DAT	2 DAT	7DAT	9 DAT	11DAT	14 DAT
Untreated check		82	70	71	83	100	80
Esteem 0.86EC	8fl.oz/100gal	82	100	8	11	8	71

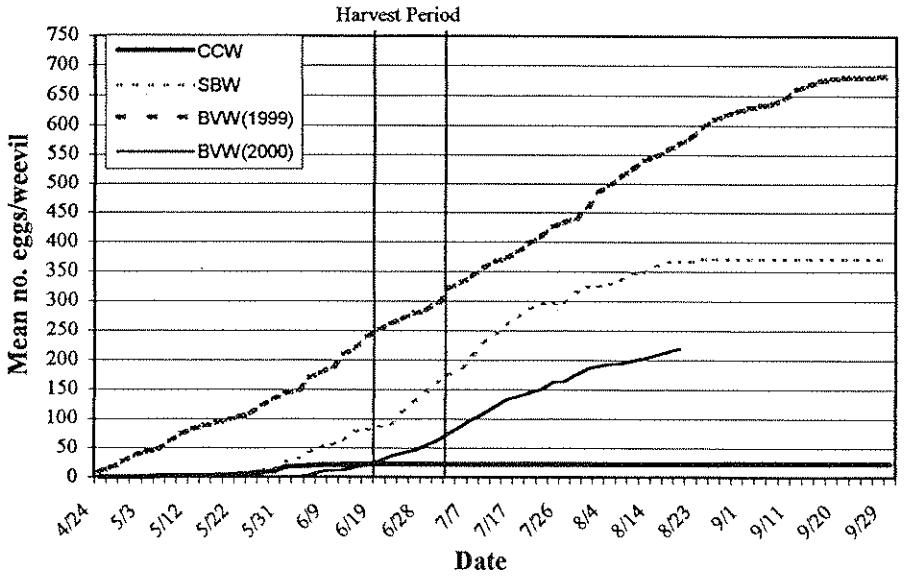

Fig. 1: Cumulative egg production for all root weevils studies, 2000.

Project No.: 13C-3543-5272

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

Year Initiated: 2000 **Current Year:** 2001 **Terminating Year:** 2002

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

Justification: Grower understanding of the seasonal phenology of the black vine weevil, *Otiorhynchus sulcatus,* has resulted in excellent statewide reduction of their population levels and economic management of adults below economic standards in red raspberry. However, regional research and understanding about aspects of life history, seasonal occurrence, reproductive potential, population dynamics and insecticide efficacy for the "other" root weevil species is less clear compared with the black vine weevil. Furthermore, empirical field observations suggest that controls and biological understanding of the black vine weevil does not necessary translate across to these other species. However, EPA/FQPA's potential changes 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. Continue life history studies (ovipositional rates, fecundity, longevity) to further characterize the biology of the black vine, strawberry, rough strawberry, clay colored and obscure weevils.

2. Continue lab and field evaluations with experimental insecticides for their efficacy to control the four major *Otiorhynchus* species of root weevils common to commercial red raspberry in Washington.

3. Continue red raspberry resistance screening for black vine weevil with feeding and egg laying bioassays.

Procedures:

1. Both overwintering adults and teneral (soft bodied, new) adults of respective root weevil species will be placed in individual Petri dishes provisioned with a bouquet of 'Meeker' leaflet placed in a vial with water and a cotton stopper and changed as needed. The number of eggs laid between observations will be recorded for each female. This parameter will be monitored until the female dies or ceases laying eggs. Thus we can obtain information on weevil longevity, eggs/day, and total eggs laid (i.e., fecundity). These data sets will be conducted in controlled climate room held at about 65 °F and variable photoperiods similar to seasonal changes.

2. Laboratory maintained colonies of various root weevil species collected during the current year will be held in a climate room held at about 65 °F and fed continuously with 'Meeker' foliage. Mature females will be sprayed with labeled rates of several experimental insecticides from a Potter spray tower and their mortality will be compared with the standard field rate of Brigade (Sect. 18).

3. Field trials for black vine weevil adult control (if available) will be conducted to evaluate and compare experimental neonicotinoids and Brigade applied as either basal or over-row applications. These two tactics will be applied with a tractor mounted 6 tank plot sprayer equipped with an over the row boom for which nozzle configurations can be altered and modified. Posttreatment evaluation will consist of visual sampling taken in late evening with 10 ft long by 3 ft wide drop cloth placed on either side of the row.

4. Short term feeding periods, repeated over three to four intervals during the season, will test cohorts of maturing black vine weevils to several red raspberry breeding selections and *Rubus* spp.

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 used as part of a rotation program will prolong the

development of resistance or potential to flare-up spider mites. 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:

		2001
01	Temporary employee	$4,000
07	Employee benefits (16% of 01)	640
Total		**$4,640**

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: 2000

Accomplishments: Preliminary red raspberry aphid trials were conducted in a first year 'Meeker' planting in the Northwood area, northeast of Lynden, in Whatcom County. The experimental neonicotinoids, thiamethoxam (Actara), imidacloprid (Admire), acetamiprid (Assail) and two rates of the highly specific aphicide, pymetrozine (Fulfill) were compared with the industry standard malathion. Weekly mite brushing samples were taken from replicated single (CT) and split trellis (ST) plots to ascertain if their were ecological and physiological affects of canopy architecture and nitrogen levels on yellow spider mite population dynamics.

Two quick and simple adjustments made to a Littau "over the row" harvester resulted in increased yields of 23% for a 20 in. split trellis compared to a conventional trellis. This confirms the effectiveness of the machine adjustments that were used in one trial last year that resulted in a similar yield increase. The 20 in. split width appears to be the optimum width to use with "over the row" Littau harvesters. A nitrogen study evaluating N rates from 0 to 150 lb./acre was implemented in Burlington.

Fruit rot was assessed in both the split trellis and nitrogen trials. 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. The question in the nitrogen study was to see if the incidence of fruit rot would increase in the first year of nitrogen application and would the increase be related to the amount of nitrogen applied.

Advanced raspberry selections from the WSU breeding program were evaluated for machine harvestability in Lynden.

Results: Five aphicides were evaluated for efficacy to control late summer raspberry aphid on a first-year 'Meeker' red raspberry field. 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 (thiamethoxam) and Assail (acetamiprid) provided quick knockdown at 2 and 12 days after treatment (DAT). The two experimental rates of the highly selective and systemic Fulfill showed no knockdown effect until after 2 DAT. These results for Fulfill are in agreement with its unique mode of action whereby aphids stop feeding shortly after exposure and mortality 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.

In 2000, yield of the ST vs CT was again compared in "Meeker" red raspberry. A new 20 in. ST with metal crossarms was established in a grower's field in Burlington, WA. A Littau "over the row" harvester with a 50 in. throat was used for most of the season. For a second year, 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. Harvest of excessive green fruit was avoided by adjusting the beater speed until fruit quality was acceptable. Yields for ST were 23% greater after 11 harvests, but finished at a 17.5% increase when the grower switched to a very narrow throated (32 in.) machine. Data from this and other trials this year confirm that the 20 in. ST is the optimal width to harvest using Littau "over the row" machines. Similar yield increases were seen for the ST in southwestern WA trials. In one trial in Ridgefield, yield was increased 22% for a 17 in. ST that was machine picked with a 39 in. throat Littau "siderow" harvester, thus expanding the range of machines that can successfully harvest a ST. Yield increases of this magnitude (around 20%) will generally increase profits for growers by approximately 15% per acre after deducting increased costs attributed to the ST.

Mite populations were monitored in the ST vs the CT in Burlington. 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 two trellis treatments for 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 ST 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. The effect of canopy thermal units and nitrogen levels on the density of yellow spider mites for each trellis system has not been analyzed.

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 full 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. Few differences were found in either trial suggesting that the traditional methods used to assess fruit rot are not precise enough to detect small changes in fruit rot due to changes in the micro-environment caused by modifying the architecture of the plant canopy. *Botrytis* was significantly lower in sprayed treatments of the ST vs CT on one harvest date, possibly suggesting that the ST type may enhance pesticide penetration or coverage. No apparent differences for *Botrytis* were noted between trellis types in unsprayed plots. Data from processed fruit evaluations are still being analyzed but again differences are slight. It was observed that berries in the ST were mainly on the outside of the canopy while those in the CT were more evenly distributed throughout the canopy. With ST training, the center of the canopy only remained open until the rapidly growing primocanes filled the void about late bloom. Few cane lesions (*Botrytis* and spur blight) were observed in either trellis or nitrogen trial.

Optimal fertilization timing and quantity remain a question in raspberry. In 2000, a field of moderate vigor in Burlington was blocked in a randomized complete block design (RCBD) with applications of 0, 50, 100 and 150 lb. granular N/acre applied as a split application in the spring. Plots were entire row lengths. Actual (machine picked) and estimated yield, yield components, biomass partitioning, primocane growth, soil and leaf nitrogen data were collected. Most data have been analyzed. While there were no statistically significant differences between treatments in any of the above mentioned data, the untreated check consistently had the lowest values for actual yield and yield components. Recent work by Strik et al. at OSU with trailing blackberry demonstrated that Pacific Northwest soils are generally quite fertile and so it may take some time before differences between treatments are seen in a nitrogen study of this kind. Unfertilized plants may show no effects early in the study because they are utilizing mineralized nitrogen available to them in the soil. Soil temperature is being monitored at six and twelve inches below the soil surface. Fruit firmness and fruit rot were assessed and data analysis is ongoing.

Advanced raspberry selections from the breeding program were evaluated at the Honcoop Farm in Lynden for machine harvestability. WSU 1090 and 1097 scored the highest for fruit firmness and volume, and for lack of mold and green fruit. WSU 1024 and WSU 1099 also harvested well for volume, but fruit quality was not quite as good.

ACKNOWLEDGMENTS: We express our appreciation to the many people in the red raspberry industry who have supported this program by allowing us to work in their fields, especially Sakuma Bros. Farms Inc, Randy Honcoop, Raj Bathe, Rob Dhaliwal and Rader Farms. Special thanks to Curt Maberry Farms for their hospitality and professional courtesy in providing facilities and site based assistance for the satellite project. This cooperative model would have never developed without the assistance and support of the industry.

PROJECT NO: 13C-3755-5967

Year Initiated: 2000 **Current Year:** 2001 **Terminating Year:** 2002

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 REU
Patrick P. Moore, Plant Breeder, WSU Puyallup REU

Cooperators:
Craig MacConnell, Chair, Whatcom County WSU Cooperative Extension

Justification:

The partnership. The concept for a satellite facility in 1996 brought federal, state, and industry resources together to cooperatively address research needs of red raspberry growers in the northern counties of western Washington. At the same time, it enhanced the role of WSU Cooperative Extension in education and technology transfer. Grower identified and prioritized projects were addressed in a cost efficient manner. The facility was staffed from spring to fall by a project manager and assistants who worked with cooperating growers in their fields and with the IPM Coordinator in Northwest Washington to conduct the numerous projects. Scientists, students and staff from Vancouver and Puyallup traveled to test sites in Skagit and Whatcom Counties to establish and monitor these field experiments. The flexibility of this facility allowed for changes in research emphasis from year to year and the participation of different researchers and cooperators. This research proposal builds on the success of this cooperative model and outlines activities to continue to address high priority needs of the red raspberry industry.

Contributions. This project will continue to provide on site staffing for important short and long term projects. As before, WSU will contribute equipment (i.e., vehicles, computers, lab equipment), graduate students, and the time of state funded scientists (Tanigoshi, Bristow, Klauer, Moore and Chen). Industry will house our personnel and provide grant funding for hourly labor, travel to the northern sites, small equipment and supplies.

Advantages. There are many advantages in this arrangement for industry and WSU. It is a cost-effective way to pursue certain types of research which we otherwise could not do without a local base of operation and support. The satellite concept enhances the link

between research and extension. It has also leveraged other sources of funding in order to enhance research activities across the entire industry.

Objectives:

1. Establish a base of operations for locally managed, joint, interdisciplinary projects under the direction of Drs. Tanigoshi, Klauer, Chen, Moore and Bristow.

2. Conduct root weevils, spider mites, and aphid damage assessments and chemical control testing in commercial fields and laboratory bioassays on treated red raspberry foliage.

3. Evaluate advanced red raspberry selections already in grower trials for adaptation to machine harvesting.

4. Evaluate modified nutritional regimes to maintain productivity while reducing the influence of nutrition on fruit rot and potential groundwater contamination.

5. Continue to evaluate the split-trellis as a cultural means of increasing production per acre with emphasis on yield sustainability and pest dynamics.

6. Evaluate cultural and chemical methods of controlling root rot under field conditions in Skagit and Whatcom Counties.

7. Investigate the interaction of nutrition and trellis design on fruit diseases, particularly gray mold caused by *Botrytis cinerea*.

Procedures:

Entomology. A field known to be infested with clay colored weevil will be blocked in a RCBD with the application of several experimental weevilcides and the standard Brigade being applied as a full coverage spray or as a basal application placed along the lower 2-3 feet of the fruiting canes. Given the opportunity, a like design will be applied for black vine weevil. Field collected individuals of the BVW, strawberry and rough strawberry root weevil will be bioassayed for contact and stomach in Petri dishes from red raspberry treated foliage. Various spider mite populations will be evaluated for their feeding and contact susceptibility to several experimental (e.g., pending registrations) acaricides at suggested field rate(s) on air-dried foliage treated with a precision Potter spray tower. Field trials initiated last season in the Northwood area, with experimental biorationale aphicides, will continue on "baby" fields infested with red raspberry aphids, especially during harvest and the long postharvest period. Petri dish trials with treated foliage will also be conducted. Our lab testing protocols in Petri dish arenas provide more controlled testing when the materials are applied with the Potter spray tower or a hand-held compression sprayer to run-off.

Horticulture. *TRELLIS STUDIES*. In the last two years, two simple machine adjustments made to Littau "over the row" and "siderow" harvesters with throats 39 in. or greater have resulted in increased yields of approximately 20% for the split (ST) vs. the conventional trellis (CT). We have shown that yields of this magnitude will offset any increased costs attributed to the ST, returning a net profit of approximately 15% more $/acre. While we understand many aspects of the plant's performance/physiology within this system, two areas of research deserve further work, long term sustainability of yield and pest/disease dynamics. We have just learned how to increase yield using simple machine adjustments. This has now been tested successfully in several fields, but not in any one field for more than one year. While we think ST yields of this magnitude will be sustainable, it is important to test this over a period of time in the same location before recommendations for major production changes are made. With the ST we are making a dramatic change in the raspberry canopy. This change may result in changes in fungal, insect and mite dynamics over time. Last year, we saw minor differences in fruit rot and potential differences in mite populations for the first time between trellis types. For the first time, we compared ST and CT that were unsprayed with fruit rot fungicides. We propose to focus our efforts on these areas of research and scale back much of the horticultural measurements that have already been well documented. At the Burlington trellis site, yield, canopy damage and machine fine-tuning data will be collected. Some ST and CT rows will be left unsprayed with fruit rot fungicides, rot quantified, and predator and pest mite populations will be extensively monitored. We will continue to collect environmental data using HOBOs and compare these data with pest population dynamics. We will continue to monitor costs/benefits associated with this system.

NITROGEN STUDIES. Optimal fertilization timing and quantity remain common questions in raspberry. These practices vary widely, especially with regard to the total amount of nitrogen (N) applied per year. N is usually applied in granular form in the spring, and then supplemented by most growers with foliar applications throughout the season, often in conjunction with fungicides. A small percentage of the total industry fertigates. Some growers base their applications on soil/tissue analysis; others do it in an "intuitive" manner by looking at the plants. Amounts applied will vary greatly depending upon soil type and rainfall. Pacific Northwest Extension Bulletin 176 recommends granular rates of 40-100 lb. N/acre usually applied as a single application in the spring. These recommendations are based on research conducted some time ago with varieties other than Meeker and are now being questioned by growers. N rates need to be reevaluated with Meeker to determine what levels are optimal for yield and fruit quality under northern WA climate and soil conditions. In addition, a better understanding of fertility needs will arm growers with knowledge that can be used to better address groundwater contamination questions, should they arise.

In 2000, a field in Burlington was blocked in a RCBD with applications of 0, 50, 100 and 150 lb. granular N/acre applied in a split application in the spring. These treatments will be repeated in spring 2001. Foliar applications of N will be quantified, but unvaried between treatments. Yield, yield components, biomass partitioning, canopy and primocane growth, tissue and soil analyses will be performed. Leaf physiological characteristics (gas exchange and chlorophyll content) will be analyzed when possible. Intact leaves will measured with a chlorophyll meter during the season to determine if N

differences are present. This experiment is being followed over three years in order to fully evaluate the treatments. Data from this site in 2000 indicated there is likely a lag effect with lower treatment rates as excess nitrogen within the plant system and soil is expended in the first one or two years. It is likely that there will be some cumulative effect observed with time.

Breeding. Fruit harvested by machine from the different selections will be inspected as it passes over the belt to look at fruit quality and the harvesting of underripe fruit. Plants will be examined for missed ripe fruit and lateral damage. The ground will examined for dropped fruit.

Plant Pathology. Results from 2000 suggest that reductions in the incidence of fruit rot due to modifications in the plant canopy (nitrogen use and ST) are small. In our 1999 fungicide trial, adding nutrients (NPK) to fungicides applied during bloom and the berry development stages did not increase fruit rot. In short, fungicides will still be needed for disease control. One reason for the lack of differences may have been the methods used in 2000 (two types of post harvest tests). During 2001 we propose to collect fruiting laterals weekly during and immediately after harvest to assess the health status and fate of each flower/berry position. Berries that rot before harvest remain attached to the receptacle and are not removed by the mechanical harvest providing a record of disease and crop development up to the time laterals are collected. Also, berries from every plot will be collected as they come off the harvester belt (for selected harvests) and assessed for fruit rot including spot rot (rot that appears on one or only a few drupelets. Canes will be monitored for *Botrytis* and spur blight lesions and if sufficient symptoms appear canes will be collected from every plot after harvest and evaluated for disease incidence.

We will evaluate cultural and chemical methods of controlling root rot under field conditions in Skagit and Whatcom counties. For a number of reasons it was not possible to begin this work in 2000. Damage from root rot caused by the soil-borne fungus *Phytophthora fragariae var. rubi* was markedly reduced when red raspberries were grown on raised beds formed with soil amended with high rates of gypsum. In addition solarizing soil the summer before planting has reduced damage from this root disease into the second growing season. These experiments were conducted at a site in SW Washington with poorly drained soil. Root rot in Skagit and Whatcom counties is associated with low areas of fields but the soil is sandier and better drained than the trial site in SW Washington. Several growers in Whatcom County routinely grow red raspberries on raised beds or slope the soil away from the plants toward the center of the alleyway. These practices reduce the time the root system remains in saturated soil during the rainiest periods.

During 2001, two test sites will be established on commercial farms where root rot is a problem (one in Skagit and one in Whatcom Counties) to evaluate raised beds, gypsum and soil solarization for disease control. Plots with and without current root rot fungicides will be included as treatments for comparison. These trials will be followed over a period of three years to document plant survival and productivity.

Anticipated Benefits and Information Transfer:

Benefits. New and cost effective cultural and pest management strategies can be developed from integrated, holistic research. The development of new chemical and cultural controls as well as modified horticultural practices will lead to increased efficiency and productivity.

Information/Technology Transfer. The most direct method will be through grower access to researchers, students and the experiments themselves. In cooperation with WSU Cooperative Extension personnel, this information will be disseminated at local, regional and national grower and professional meetings as well as through local, regional, and national publications. We propose to hold an open house in Whatcom County after harvest, and/or at the Mt. Vernon Field Day in late July. Newsletters and other extension and industry publications will be used to update industry on new developments as appropriate. Information will be disseminated on websites (http://www.vancouver.wsu.edu/programs/cahe/wsureu/).

Additional Cooperative Research Relationships. As new research priorities are identified and developed, other scientists will be required to address various research needs at northern and southern locations within our industry. It is our intention to use flexibility and cost effectiveness of the satellite facility to attract other scientists and research programs into the red raspberry industry in northern Washington.

Budget:

	2000 Request
01 Wages (3 Temporary employees)	$12,480
03 Supplies and services (field supplies, analyses)	1,500
04 Travel (to sites)	2,600
05 Equipment	500
07 Benefits (16% of 01)	1,997
TOTAL	$19,077

In-kind Support from Industry:

Office space and access to field plots, maintenance of field plots and assistance with data collection.

Matching Support from WSU:

State vehicles, equipment (microscopes, computer, FAX, lab equipment), graduate student support, research scientist's time.

Other Support of Project:

None at present; attempts to be made for additional personnel funding.

Project No: 13C 3419 8228

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: 2000-01

Accomplishments:

The first season results evaluating the long term effects of three caneburning compounds (Goal, Enquik, and Aim) in combination with or without Casoron in 'Meeker' red raspberry have been collected. 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 Enquik (15 gal/a), and the same rates of Goal, Aim, and Enquik alone (without Casoron).

Results:

1. Burn was reasonable for all treatments and most pronounced with Goal + Casoron. Primocane regrowth was slowest with this treatment, and Casoron combined with the caneburning materials slowed primocane growth compared to the untreated check or Casoron alone.

2. Aim and Enquik burned well, but were softer on the plant and intermediate between Goal and the check in terms of primocane number, height and yield.

3. The use of Casoron improved weed control and the combination of Casoron + Aim had less of an impact on cane regrowth than the combination of Casoron with Enquik or Goal. Raspberries treated with Casoron + Enquik 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.

4. There were no significant differences in machine-picked yield between treatments, or in yield components or dry weight partitioning.

Publication:

Progress report of long-term effects of weed control/caneburning in red raspberries. 2000. WSU Vancouver Field Day, September 21.

Project No: 13C 3419 8228

Title: Caneburning and Weed Control in Red Raspberries

Year Initiated: 2000-01 **Current Year:** 2001-02 **Terminating Year:** 2002-03

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

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*), hedge bindweed (*Calystegia sepium*), and common catsear (*Hypochaeris radicata*) have long been weedy in western Washington. A newly introduced perennial species with tremendous weedy potential is yellow nutsedge (*Cyperus esculentus*), which is

listed as one of the world's worst weeds. If not controlled, these perennial weeds can be a major factor in reducing the longevity of raspberry plantings.

Objectives:

1. 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.

2. Conduct testing of herbicides for control of perennial weed species commonly infesting red raspberry blocks.

Procedures:

1. 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 each of the two upcoming growing seasons (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.

2. Perennial weed control (quackgrass and yellow nutsedge) studies will continue to be conducted on grower raspberry fields near Mount Vernon, WA. Fall weed control products of interest are Milestone (azafenidin) and Visor (thiazopyr), and spring tank mixtures applied at caneburning are Milestone, Visor, Gramoxone (paraquat), Goal, and Aim. Other products of interest include Dual Magnum (s-metolachlor), Lasso (alachlor), Frontier (dimethenamid), Topnotch (acetochlor), Spartan (sulfentrazone), Sinbar (terbacil), Basagran (bentazon), Permit (halosulfuron), Assure II (quizalofop), Fusilade (fluazifop), Poast (sethoxydim), Select (clethodim), Roundup (glyphosate), Touchdown (sulfosate), and Casoron (dichlobenil). Fall treatments will be applied to dormant, established raspberries; spring tank mixtures will be applied to established raspberry plants when primocanes are 4 to 6 inches in height. Primocane suppression and regrowth, weed control, and berry yield will be evaluated.

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 2000-01
Time-slip	$ 10,000
Operations (goods & services)	1,000
Travel	
Projected Needs	1,000
Meetings	0
Other	0
Equipment	0
Employee Benefits (16%)	1,600
Total Request	$ 13,600

NOTE: The budget would be evenly 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.

Project No: 13C-354 3-3272

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 and Extension Unit

Reporting Period: 2000

Accomplishments:

1. Unlike last year, the occurrence of CCW did not coincide with bud breakout of red raspberry this year.

2. When CCW occurred after bud breakout, it caused more damage to raspberry leaves instead of lateral buds, and therefore, did not contribute to severe bud damage and yield loss.

3. Red raspberry canes covered during winter with clear plastic sheets enhanced fruit cane growth, lateral and flower bud initiation.

Results:

The red raspberry plants in the covered sub-plots produced significantly higher fruit cane size and bud numbers per cane. Excessive heat under the plastic cover in late spring might have caused some damage to cane tips and buds because of late removal of the plastic cover. Cane dieback and damaged bud number per cane increased in the covered sub-plots. The increased fruit yield in the covered subplots, mainly through a higher fruit number per lateral and fruit weight, was not significant.

Publications:

Chuhe Chen, Lynell Tanigoshi, Stephen F. Klauer, Geoff Menzies, and J. Scott Cameron. 2000. Field Assessment of Combined Bud Damage on Floricanes of Red Raspberry Caused by Cold Injury, Clay Colored Weevil, and Spur Blight Disease. HortScience 35(3): 505 (abst.).

Lynell Tanigoshi, Chuhe Chen, and Geoff Menzies. 1999. Control and Economic Impact of the Clay Colored Weevil on Red Raspberry. 59th Annual Pacific Northwest Insect Management Conference Proceedings: 61-63.

Chuhe Chen, Lynell Tanigoshi, Stephen F. Klauer, Geoff Menzies, and J. Scott Cameron. 2000. Field Assessment of Combined Bud Damage on Floricanes of Red Raspberry Caused by Cold Injury, Clay Colored Weevil, and Spur Blight Disease. The 97th American Society for Horticultural Science Conference, Orlando, FL. 7/23-27/2000.

Chuhe Chen, Lynell Tanigoshi, Stephen F. Klauer, Geoff Menzies, and J. Scott Cameron. 2000. Integrated stress management to reduce bud damage on floricanes and to achieve high fruit yield in red raspberry. 2nd Annual Small Fruit Grower's Workshop, 2000 Proceedings: 4-8.

Lynell Tanigoshi, Chuhe Chen, Geoff Menzies, Raj Bathe, and Sam Dhaliwal. 1999. Studies of the Clay Colored Weevil on Meeker Raspberries – WSU Vancouver, Lynden Satellite Station. http://whatcom.wsu.edu, Web pages.

Project No: 13C-3543-3272

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

Year Initiated: 1999 **Current Year:** 2001 **Terminating Year:** 2001

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

Justification:

The clay colored weevil, *Otiorhynchus singularis,* is a key pest in British Columbia and recently shown to be a more frequent problem in Whatcom County. The main damage period for this root weevil begins in mid-March and extends through April. These weevils voraciously feed on unopened buds, fruiting laterals, causing leaf notching and 'flagging' by feeding on the petioles of leaves. We estimated 33% bud damage from clay colored weevil alone in our study site near Lynden in 1998. Bud damage reached more than 60% of total buds when the clay colored weevil feeding was factored with spur blight and cold damage. This further resulted in a 61% fruit yield per cane loss. Azinphos-methyl (Guthion) will control early season populations of clay colored weevil. However, this organophosphate is at risk from voluntary measures by registrants to reduce both dietary and worker risks from azinphos-methyl on cane fruits. This is, in part, due to recent activity by the Food Quality Protection Act to achieve its mandated goals.

Objectives:

1. Evaluate weevilcides which could be used to effectively control adult clay colored weevils in the future.

2. Determine impact of clay colored weevil bud damage on red raspberry yield components and associations with cold damage and spur blight.

Procedures:

1. Treatments will be full coverage sprays applied with a tractor mounted 6 tank plot sprayer with an over the row boom using 14 D3-25 TeeJet nozzles arranged in an inverted U at 200-300 psi and 3 mph to deliver 92-100 gpa.

2. A field site known to be infested with clay colored weevil will be blocked as a RCBD with three treatments each replicated four times in Whatcom County. The check will be treated 1-2 times with Brigade to chemically exclude all potential weevil species while the other two treatments will allow clay colored weevil feeding for three and six weeks before treatment with Brigade, respectively. The cold injury factor will consist of low and high exposure levels. Low cold injury plots will be covered with plastic sheeting during the winter. Six canes per plot will be sampled at the green fruit stage to assess bud damage from clay colored weevil feeding, spur blight, cold injury to estimate potential fruit yield. Undeveloped buds per cane will be counted and categorized as weevil damage, spur blight or cold damage. Primary and secondary lateral numbers per cane, flowers and fruits per lateral will be counted and lateral length measured. Fruiting canes per plot will be counted and fruit weighed five times during harvest. Photosynthetic and fluorescence parameters will be measured on five leaves per plot during the late fruit season.

Anticipated Benefits and Information Transfer:

The timely application of clay colored weevil insecticides has experimentally been demonstrated to reduce their populations below economic levels with concomitant increased productivity. This knowledge will be disseminated at grower workshops, pesticide recertification meetings, WSU Vancouver web site, extension publications and local, regional and national publications.

Budget:

Request for FY 2001-2002

01	Temporary employee	$1,000
03	Supplies (field supplies, analyses)	500
04	Travel (domestic)	1,000
07	Benefits (16%)	160
		$2,660

Project No.: New

Title: Soil solarization as a component of an integrated program to control Phytophthora root rot of red raspberry.

Year Initiated: 2001 **Terminating Year:** 2004

Personnel: Peter R. Bristow, Associate Plant Pathologist, [1]WSU-Puyallup Research and Extension Center
John N. Pinkerton, Research Plant pathologist, USDA-ARS, Hort. Crops Research Lab, Corvallis, OR

Justification: Root rot caused by the soil borne fungus *Phytophthora fragariae* var. *rubi* is the most serious root disease wherever red raspberries are grown. Fumigating the soil with methyl bromide/chloropicrin under a plastic tarp only delayed the appearance of root rot for 3-4 years. Plantings of susceptible varieties that remain healthy can be productive for 20+ years. Since the early 1980's, metalaxyl (Ridomil and more recently Ridomil Gold) has been applied to the soil to control the disease. While this fungicide continues to be effective in many plantings, it is no longer active in others. Efforts continue to breed for resistance but combining the high level of resistance needed with acceptable horticultural traits has proven difficult. As mentioned above an integrated program that includes growing plants on raised beds and incorporating gypsum into the soil helps to reduce the impact of the disease.

Soil solarization has been a successful hydrothermal process for disinfecting soil of nematodes and soil borne pathogens especially in areas such as Israel (3) and California (1) where there is ample sunlight and temperatures are very high. Because of these requirements, the maritime region of the Pacific Northwest (areas west of the Cascade Mountains in Oregon, Washington and southern British Columbia) was not thought to suitable for soil solarization. However, in a preliminary trial, solarizing soil naturally infested with the raspberry root rot fungus markedly improved the growth of two highly susceptible varieties (Qualicum and Skeena) in the year of planting. The benefits of solarization have continued into the second growing season. These results were surprising because soil at the 10 cm depth only reached 35°C for 91 hours during the 8 weeks of solarization (Jul –Sep 1998). In other work conducted in the Willamette Valley on soils solarized during the same period of late July-late September soil temperatures at 10 cm exceeded 45°C for a few hours and exceeded 40°C for more than 150 hours. Soil solarization does work in western Oregon and Washington.

Objective:

To evaluate soil solarization alone and in combination with raised beds and gypsum soil amendment in an integrated plan for controlling Phytophthora root rot on red raspberry.

Procedures: A field planting will be established in 2001 at the WSU-Vancouver Research and Extension Unit where the soil is naturally infested with *Phytophthora fragariae* var. *rubi*. The six treatments (Table 1.) will be arranged in a split block experimental design with four blocks (replications). Agricultural gypsum will be incorporated into the soil of some plots just prior to solarization. Raised beds will be formed with a commercial bed shaper before the polyethylene film is put in place. Plots of treatments calling for soil solarization will be solarized beginning in late July 2000. The plastic will be left in place at least through planting the following spring. Temperature probes connected to a datalogger will continuously record soil temperature at 10 and 30 cm depth. Soil temperature will be recorder in flat and raised beds both with and without the plastic tarp. Tissue culture-propagated plants of two susceptible red raspberry cultivars will be planted in spring 2001 and a drip irrigation system will be installed at the time of planting. To reduce the risk of recontamination of solarized plots a perennial cover crop will be planted between rows and between plots within the row. Plant growth and disease incidence and severity will be assessed for up to three crop seasons. Data will be analyzed statistically.

Table 1. Treatments.

No.	Description	Bed type	Gypsum*	Solarization
1	Flat/No solarization**	flat	no	no
2	Raised/No solarization**	raised	no	no
3	Flat/Solarized	flat	no	yes
4	Raised/Solarized	raised	no	yes
5	Raised/Gypsum/No solarization	raised	yes	no
6	Raised/Gypsum/Solarized/	raised	yes	yes

* 6 tons per acre.

** these treatments are considered as check or control treatments.

Gypsum has been shown to be fungitoxic to *Phytophthora* spp. and it reduced the severity of root rot on red raspberries in other tests at this site. Control has been best when several approaches have been used in an integrated program. Growing red raspberries on raised beds has markedly lowered the severity of the disease and increased the productive life of plantings.

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 artifically 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:

Request for FY2001-02	
Timeslip labor	3,800
Operations (goods and services)	1,000
Travel	
Project needs	300
Meetings	100
Equipment	1,300
Employee benefits	610
Total	$7,110

Other Support of Project: None at this time.

Title: Epidemiology, detection, and management of tomato ringspot virus and *Xiphinema americanum* in red raspberry. 91

Personnel: 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.

Report Period: 2000

Accomplishments: In fall 1998, plots were established in a raspberry field in Vancouver, WA with a high incidence of TomRSV. Five treatments are being evaluated for reducing TomRSV is a subsequent raspberry planting; perennial grass maintained weed-free, rape (canola), clean fallow, fumigation with methyl bromide, and raspberry with mixed grass-weed (control). Red raspberries were planted in the plots this spring. Soil has been collected in the plots each spring and fall to determine the effects to treatments on nematode densites and TomRSV. The reoccurrence of TomRSV in the new planting will be monitored by ELISA for 3 or more years.

Techniques are being developed to assay the soil and nematodes for the presence of TomRSV. In the soil assay, cucumber seedling are planted in soils collected at the study site. After 4 weeks, leaves are tested for TomRSV with ELISA. Techniques also are being developed to directly monitor TomRSV in the nematode population by immuno-capture reverse transcription polymerase chain reaction and immunofluorescence.

Population dynamics of *X. americanum* are being monitored monthly in the study site. The soil is tested for TomRSVwith the cucumber assay. When immunofluorescence and ELISA techniques are available, they will be used to study the spread of TomRSV in the nematode population and raspberry planting. Distribution of TomRSV in the plant root system and its relationship to acquisition of the virus by the nematode will be studied using ELISA or PCR.

Results

Rotation experiment. Population densities of *Xiphinema americanum* were reduced significantly from fall 1998 to spring 2000 by clean fallow (79% reduction), rape (70%), and fumigation (98%), but not in the grass plots (17%) or raspberry control plots (15%). The methyl bromide was applied on the soil surface under a tarp which may explain the survival of the few nematodes recovered from the soil. At planting, soil from the fallow, grass, rape, and fumigation plots tested by the cucumber assay were negative for TomRSV. However, TomRSV was detected in plots that had been maintained in raspberries.

Assay techniques. The cucumber assay consistently detected the presence of viruliferous nematodes in the population dynamics plots where raspberries were both symptomatic and symptomless of TomRSV. We have explored various methods to prepare the nematodes, but have not detected TomRSV in nematodes yet. Since obtaining virulferous nematodes from field soil has been difficult, we are infesting nematodes in soil planted with TomRSV inoculated cucumbers. These nematodes will be used in future experiments designed to study sensitivity of immunofluorescences and PCR methods.

Epidemiology. During the last two years, *Xiphinema* population densities were the highest in early winter, declined through the summer, and increased in early fall. In contrast, the greatest proportion of cucumber assay plants that were positive for TomRSV were grown in soil collected during the spring and summer. One hypothesis is that the nematodes are less active in the winter and less likely to acquire the virus in the period.

Management and Control of Tomato Ringspot Virus

Year Initiated: 1999 **Current Year** 2001 **Terminating Year** 2003

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

Justification

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 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 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.

Specific Objectives for 2000-2001:

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.

Objective of project beyond 2001

The specific objectives of the project will require five years to complete. Additional funding is being sought from other sources. (Oregon Raspberry and Blackberry Commission, Northwest Center for Small Fruit Research)

Procedures to be used:

To develop a method to detect virus in nematodes several strategies will be employed. The first and simplest is to use ELISA. This will be done with groups of nematodes, probably between 10 and 25 per group. While using ELISA we will optimize a method to release virus from nematodes for the assay. With groups of nematodes from an infected field we should be able to detect virus by ELISA. Once we can optimize extraction of virus from nematodes we will compare ELISA and, PCR, RT-PCR and Immunocapture RT-PCR (IC-RT-PCR) for the method which has the greatest sensitivity for detecting virus in nematodes. We also will develop immunofluorescence techniques that will allow us to discern the presence of TomRSV in

individual nematodes with microscopy. The reason for optimizing the sensitivity is that we wan93 to be able to monitor changes in virus content in the nematode population and to develop a diagnostic tool for TomRSV in field soils.

The monitoring of virus in nematodes over time will be used to follow virus titers in nematodes when they are: 1. feeding on host and nonhost plants for the virus; 2. surviving in a quiescent state during a fallow period and during adverse environmental conditions; 3. nematodes that survive fumigation by being below the zone of soil that is treated with the fumigants.

The optimized test for detecting TomRSV in nematodes will be used in further studies to monitor the acquisition, transport, and inoculation of TomRSV in a raspberry planting. Leaves and roots of primocane and floricanes will be sampled over time to determine seasonal pattern in TomRSV titer in raspberry plants. Nematodes will be evaluated for the presence of TomRSV in soil samples collected at periods corresponding to the collection of plant material. Soil samples also will be collected at various distances from discrete TomRSV foci (infected plants planted in field free of TomRSV) to determine relationship of numbers of viruliferous nematodes the rate of disease spread in and between plant rows.

'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 the spring of 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. Each transgenic line will also be graft inoculated with TomRSV in the coming year to determine if they are resistant to graft transmission, often considered the most severe form of challenge. Plants that are resistant to graft transmission will be evaluated for copy number of the inserted gene and protein expression levels (in the case of coat protein gene). Once in the field plants will be tested annually by ELISA to monitor for infection by TomRSV.

Anticipated Benefits and Information Transfer:

Development of a risk assessment tool to evaluate potential of TomRSV developing in a raspberry field and development of a means to purge nematodes of TomRSV prior to planting a field where the risk of virus infection is high. A better understanding of the dynamics involved in epidemiology and ecology of *Xiphinema* and TomRSV. Development of raspberry plants with genetic engineered resistance to tomato ringspot virus.

Information will be presented to growers at commission meetings and short courses. Information will be published in scientific journals.

Research Timetable:

2000-2001. Techniques to detect TomRSV in individuals and populations of *X. americanum* are being evaluated and refined. Field plots were planted with raspberries. Reinfection of plants is being monitored. The seasonal distribution of the virus in the nematodes and plants will be monitored. Transgenic plants will be established in the field and graft inoculated in the screenhouse.

2002-2003. Plots will be established to study the spread of TomRSV from discrete foci in a raspberry planting. The same parameters will be monitored as in 2000. Transgenic plants will be evaluated for field resistance to infection of TomRSV by nematodes and for fruit quality. The

research data will be analyzed and summarized for the small fruit industry and manuscripts will be prepared for publication.

Budget:

Amount allocated by Commission in FY 2000:	4,750	
Request for FY 2001	5,300	
Student Labor		4,000
Operations:		
Plasticware (ELISA plates, PCR tubes and plates)		500
Enzymes		300
Immunofluorescence mircoscopy supplies		500
Total		5,300

Other support of the project: (2000)

Northwest Center for Small Fruit Research	9,928
Oregon Raspberry and Blackberry Commission	2,000

Applications to both of the above are being made again for the year 2001

Project No.: New

Title: Evaluating root growth and plant productivity in relation to irrigation method and flat versus raised beds.

Year Initiated: 2001 **Current year:** New **Terminating Year:** 2005

Personnel: Stephen F. Klauer, and Chuhe Chen, Research Associates WSU Research and Extension Unit, Vancouver
Peter R. Bristow, Associate Plant Pathologist, WSU Research and Extension Center-Puyallup

Justification: Root rot caused by the soil-borne fungus Phytophthora fragariae var. rubi is the most serious root disease of red raspberry. Left uncontrolled, it can devastate a planting within a few years. Until recently, use of the fungicide, Ridomil (metalaxyl), has given good control of this disease, but it is no longer adequate in some locations. The fungicide Aliette (fosetyl-Al) has been less effective than Ridomil and there are no other chemicals currently available for this use. The two most common varieties grown commercially in the Pacific Northwest, Meeker and Willamette are not resistant to this disease and there are no satisfactory replacements with resistance to the disease.
In addition to the testing of new fungicides, other alternatives are being explored to control this disease. They have resulted in the last few years in an integrated approach to controlling this disease using a combination of cultural and chemical practices. These include planting on raised beds 12–14 inches high, incorporating gypsum into the soil, improving soil drainage by "ripping" the soil between rows and use of currently available fungicides.
Work by scientists in New York, and by Bristow in Washington has demonstrated that planting raspberries on raised beds decreases the severity of root rot disease dramatically. Bristow has shown that soil in raised beds is significantly drier than soil in flat beds at comparable depths, especially in the upper regions of the soil profile. It is thought that drier soil impedes the ability of the fungus to spread. Soil near or at saturation is needed for the fungus to produce motile zoospores and once produced for them to move through soil.
Because of the success of raised beds in contributing to the control of this disease, growers are increasingly adopting this practice. They are putting new plantings on raised beds and are renovating existing plantings using field implements to throw soil up around the crowns of existing raspberry plants. This creates a ridge of soil for new roots to grow into. This process is repeated yearly to maintain the bed or ridge at a height of 12 inches or more.
What has not yet been evaluated is the effect this practice has on the general physiological performance of the plant, especially in terms of an increased potential for water stress. Water stress is the most common limiting factor to plant growth and yield. Raspberry is a heat susceptible plant that becomes photosynthetically limited above 72 F. It is especially susceptible during peak harvest when a convergence of sink demand from actively growing fruit, primocanes and roots puts a great demand on plant resources.

Lack of sufficient water during times of active growth limits fruit size and primocane number and size. We know that raised beds create a drier soil profile according to measurements made with tensiometers in the middle of the beds. We don't have a clear idea of the moisture gradient towards the outer edges of the beds. Decreased moisture may be inhibiting plant growth and productivity to some degree while it also inhibits fungal activity. Plants on raised beds may be more prone to water stress especially during periods when high temperatures/drying winds and high sink demand converge. If this is the case, there may be a balancing point yet to be found where irrigation can be increased to optimize plant productivity, without counteracting the beneficial effects of raised beds on root rot. Understanding these factors is critical if raised beds are to become the industry standard.

Objectives:

1. To determine if there is a difference in water stress, yield and physiological performance between plants on raised beds and those on flat beds under the same well-watered conditions.
2. To gain a better understanding of possible moisture limitations within raised beds by developing a 3-dimensional profile of soil water and temperature conditions within raised vs. flat beds.
3. Establish a one-acre planting incorporating raised and flat beds with drip irrigation and fertigation capabilities for irrigation, water stress and future fertigation studies. Almost half of this cost is already covered by funds provided by WSU (ARC) and plant donations.

Procedures: Objective 1: A planting already exists at WSUV R and E Unit where the performance of Meeker and Skeena red raspberries is being evaluated under various treatments for root rot on raised and flat beds. Plants receiving the optimal protection (Ridomil + gypsum) for root rot on raised vs. flat beds will be evaluated. These plants will be well-watered using overhead irrigation (timing and quantity of irrigation as determined by the evaporation pan method at WSUV R and E Unit). Plants will be evaluated for water stress before and after irrigation to determine if there are differences. Water potential will be compared using a pressure chamber. Yield, berry size and primocane growth will be compared. Overall physiological performance will be assessed by measuring CO2 assimilation and leaf: fluorescence, chlorophyll content, 4th derivative spectra and N content. These parameters can often indicate plant stress. Because these plots are already part of an ongoing root rot study, data from that study assessing root rot within these plots will be examined for effects within the context of this study.

Objective 2: Additional tensiometers will be added to existing sites within this planting at various distances and depths away from the center of the raised and flat beds to compare soil moisture tension. Soil core samples will be analyzed for water content. Soil temperature within raised and flat beds will be monitored using relatively inexpensive HOBOs.

Objective 3: Because much of the industry is moving from overhead irrigation to drip irrigation, evaluating objectives 1 and 2 for plant performance, yield and water stress under the drip system is essential. Also, plant performance on raised vs. flat beds has always been evaluated in the context of root rot studies in soils heavily infested with the organism causing this disease. To truly assess plant performance on raised beds, the root rot variable must be removed by fumigating soil in a new planting that will have raised and flat beds. To further reduce the influence of root rot the soil will be amended with gypsum prior to planting and plants will be treated with fungicides. Lateral lines to each row in the drip system can be cheaply fitted with shut-off valves so that different irrigation regimes can be applied within the planting to better evaluate plant stress related to irrigation practices. WSUV R and E Unit currently has many of the materials necessary to establish this planting, but the purchase of some materials would be required. Plants will likely be donated.

Anticipated Benefits and Information Transfer:
Benefits: Root rot disease has a major impact on yield. Controlling this serious disease will require an integrated approach, a major part of which is planting on raised beds. Many growers are adopting this practice. Because raised beds have been shown to be drier, it is possible that plants on these beds behave differently, especially in terms of water needs. This study will tell us specifically if the plants on raised beds are more water-stressed than those on flat beds, and will give us a good general comparison of overall plant performance in relation to this cultural practice. Depending on our findings, changes in irrigation practices may be indicated in order to optimize productivity in this cultural system. Understanding the moisture profile throughout the raised bed will lead to a better understanding of how evenly water is distributed in the bed, and what effects this might have on plant growth.
Information/Technology Transfer: Information from this project will be disseminated at local and regional grower's meetings. It will be incorporated into WSU Cooperative Extension publications where appropriate. The results will be combined with results from other research for publication in scientific journals.

Budget:

Request for FY 2001-2002 (Objectives 1 and 2)	
Timeslip labor	$5,265
Operations (goods and services)	500
Travel	
Project needs	300
Meetings	100
Equipment (HOBOs and tensiometers)	1,400
Employee benefits	842
Request for FY 20010-2001 (Objective 3)	
Equipment	$2,100
Total	**$10,507**

PROJECT NO: New

TITLE: Integrated Organic Raspberry Production and Pest Management Study

YEAR INITIATED: 2000 Current YEAR: 2000-2001 TERMINATING YEAR: 2003

PERSONNEL: Co-Principal Investigators
Chuhe Chen and Stephen Klauer, Research Associates
Carol Miles, Associate Horticulturist and Extension Specialist
Charles Johnson, Plant Physiologist and Mycorrhizologist, WSU Vancouver REU
Peter R. Bristow, Associate Plant Pathologist, WSU Puyallup REU

COOPERATORS:
Jan and Dean Pigman, Organic growers, Pigman's Organic Produce, Olympia
Martin Nicholson, Ag and Research Operation Manager, WSU Vancouver REU

JUSTIFICATION:

In the US, the annual growth rate of organic food products is 24%, and is one of the few bright spots in an otherwise depressed agricultural product market. Foreign berry producers are however geared up for supplying much of the high-end organically grown berries in the US. Some local growers are entering into organic berry production to meet this new demand but they require innovative organic pest management strategies. A major pest challenge for organic berry production is root rot (*Phytophthora*). Currently raspberry production systems depend on methyl bromide soil fumigation to control soilborne pests including root rot. Methyl bromide is not permitted in organic production and its usage for soil fumigation in the U. S. will be banned by 2005. Looking ahead, the section 18 registration of other chemicals will become more difficult as the pressure for environmental protection increases. This will increase the urgency for developing alternative methods for disease management.

Drs. Peter Bristow and Carol Miles conducted research in 1995-96 to test raised beds for raspberry root rot control. Dr. Bristow expanded this work at the WSU Vancouver REU to include raised beds and gypsum. Our proposal is an expansion of that study, and will test the efficacy of two biological control products *Trichoderma* (T-22) and *Gliocladium* (G-41), and will also test the efficacy of soil amendments, gypsum and composted manures. Both biological products are registered, but neither is labeled for root rot control of raspberries. The trial was initiated at Pigman's Produce in 1998 and was expanded to Vancouver in 1999. The soils of both selected sites are infected with *Phytophthora*. Preliminary results of our study indicate that the manure treatments produced the highest yield at each site and a very significant yield increase over the control, and was higher than the Ridomil treatment at the Vancouver site (Appendix). The beneficial effects of manures may be due to the suppression of *Phytophthora* and improvement of plant nutrition. A new trial is proposed to separate the effects of manures

on nutritional benefits from root rot suppression. Results will enable growers to develop sustainable berry production systems.

Another component of our study is mycorrhizal research, which for the past century has focused on improving crop nutrient uptake and yield. Mycorrhizae have also been shown to reduce damage caused by soilborne pathogens. However, no studies on the use of mycorrhizae to manage *Phytophthora* have been conducted in berry crops. Dr. Charles Johnson has conducted many studies on mycorrhizae to improve growth and nutrient uptake in ornamental crops. He has joined our research team to provide the much-needed expertise to conduct the proposed mycorrhizae research on berry crops.

A final component of our study is gray mold fruit rot (*Botrytis cinerea*) control. Fruit rot is one of the most destructive diseases of raspberry crops. The stamens and stigmas of flowers are major pathways of infection, and adequate spray coverage of flowers is problematic. Long flowering time, canopy coverage of flowers, and a short viability period for individual flowers require multiple sprays throughout flowering resulting in increased costs to growers and health concerns for consumers. More effective means are needed for controlling fruit rot in berries. Bees have been used successfully to deliver *Trichoderma* to strawberry flowers to control fruit rot, and proved to be a more efficient way to deliver biological control agents to the crop. A spray test is a simple first step to determine the effectiveness of the biological agents in raspberries.

OBJECTIVES:

- Analyze and compare performance of different integrated methods to control root rot at WSU Vancouver REU and in an organic growers' field.
- Investigate the effects of manures on the suppression of root rot and the nutritional impacts on raspberry yield.
- Investigate the impact of mycorrhizae on root rot development and raspberry yield, and the effects of different organic and chemical agents used in this study on mycorrhizae populations in the roots.
- Investigate the use of biological agents for gray mold fruit rot control, and their physiological and pathological mechanisms.

PROCEDURES:

The primary site for our root rot control study is an eight-acre field of 'Meeker' raspberries established in 1997 at WSU Vancouver REU, in a raised bed planting with drip irrigation. The secondary site is Pigman's Produce, a certified organic commercial farm in Nisqually, Washington. At Vancouver, the study design is a randomized complete block with 4 replications and 7 treatments that are all soil applied – T-22, gypsum, G-41, composted dairy manure, composted dairy manure inoculated with T-22, Ridomil, and the control. At Pigman's Produce, the study design is a split plot with 3 replications where the main plot treatment is soil level (flat or raised bed) and sub-plots are soil applications. The study includes 6 sub-plot treatments – T-22, gypsum, composted chicken manure, composted horse manure, composted horse manure inoculated with T-22, and the control.

A second study will be established at Vancouver to investigate the nutritional impacts of manures on raspberry fruit yield. Treatments will include a combination of manure, Ridomil and gypsum, and the control. A third study will be established at WSU Vancouver REU to investigate the impact of organic and chemical agents on mycorrhizae populations in the soil-root system. We will survey mycorrhizae in the root rot study plots and we will establish a greenhouse study with a complete random design and 10 replications. The greenhouse study treatments will include a 2x2 factorial, with and without the mycorrhizae inoculation, and with and without *Phytophthora* inoculation. Our fourth study is on biological control of gray mold fruit rot and will include 5 treatments - Switch (chemical fungicide), T-22, G-41, methyl jasmonate, and the control. The plots will be foliar sprayed repeatedly according to the standard fungicide program. Physiological parameters such as photosynthetic rate and chlorophyll content will be measured in the studies to understand the physiological mechanisms in these plant-pest-control agent systems.

ANTICIPATED BENEFITS AND INFORMATION TRANFER:

The results from our proposed studies will support the transition of berry production in the Northwest to organic and sustainable farming systems. Results will provide berry growers with sustainable IPM strategies that are cost effective. 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. Dr. Miles will compile results into a project report to be published in regional magazines and newsletters such as Western Fruit Grower and Pacific Northwest Sustainable Agriculture Newsletter. Results will be available for the regional grower and researcher's meetings and a field day. Reports will be posted on the Agricultural Systems website, http://agsyst.wsu.edu.

BUDGET:

- Request for FY 2000-2001

Time-Slip	$10,000
Operations (goods & services)	$1,000
Travel	
Project needs	$1,000
Meetings	0
Equipment[1]	$2,000
Employee Benefits (16%)	$1,600
Total	$15,600[2]

[1] Partial funding is required for equipment needed for organic farming. The equipment we need to purchase includes a propane flame weeder and a manure spreader. WSU has funded most of our equipment purchases for this organic study. Other WSRRC funded research projects conducted at WSU Vancouver REU will share the equipment listed here.

[2] All current support is for the ongoing organic root rot control study. The commission's funding is essential to establish and conduct the proposed trials on biological fruit rot control, manure nutrimental benefits and mycorrhizae.

Appendix

Fruit size and yield (hand picked) in the integrated root rot management trials, 2000

Location	Treatment	Berry yield (g)		% Increase over the control	Berry weight (g)		% Increase over the control
Pigman' Produce Patch	Horse manure	1137	A*	87.4	2.83	AB	19.9
	T-22	1057	B	74.2	2.67	AB	13.1
	Chicken manure	963	B	58.8	3.43	A	46.6
	G-41	877	B	44.5	2.61	AB	10.6
	Horse manure + T-22	737	B	28.8	2.34	B	-0.7
	Control	607	B		2.36	B	
Vancouver REU	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
	Control	2488	B		1.73	A	

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

Current & Pending Support

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

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
Carol Miles and Chuhe Chen	Current: Organic Farming Research Foundation (14K-4167-2179)	$4,480.00	12/01/99-11/30/00	10%	Raspberry Disease Control Study
	WSCPR (10A-3093-2305)	$4,904.83	7/1/00-6/30/01	10%	Organic Raspberry Study
Chuhe Chen and Carol Miles	Pending: Organic Farming Research Foundation	$5,200.00	11/1/00-12/31/01	10%	Raspberry Root Rot Control Study
	Northwest Center for Small Fruit Research	$14,480.00	01/01/01-12/31/01	15%	Integrated Organic Pest Management Study

A:instructions00/cp2/cm

PROJECT: NEW

TITLE: Deer Fencing of Raspberry Yield Plots

YEAR INITIATED:2001
CURRENT YEAR:2001
TERMINATING YEAR:2001

PERSONNEL: Patrick P. Moore, Scientist,
WSU Puyallup Research and Extension Center, Puyallup, WA

JUSTIFICATION:
The breeding program makes controlled pollinations each year, grows seedlings, evaluates them in the field and makes selections among these seedlings. These selections are then propagated and planted in the field in replicated plots. Quantitative harvest data is collected from these selections for two harvest seasons and then decisions are made using this data to discard selections or retain them for further testing and potential release.

The 1998 replicated planting was severely damaged by deer browsing. One hundred sixty-five out of 207 plots (80%) had some browse damage. The damage was removal of the primary bud from the mid-portion of the cane in March or April. Thirty-nine percent of the buds did not break, with 28% not breaking because of browse damage and 11% from other causes. Because of the extensive damage, observations were made in the planting, but no harvest data was collected. Deer protection in the future is essential.

The 1997 replicated planting had minor damage. Thirty-three of the 146 plots (22.6%) had some browse damage. Twenty-nine percent of the buds did not break, but only 4% did not break bud because of browse damage with 25% from other causes. Because fewer plants were damaged and damage to the plants that were browsed was less extensive, this planting was harvested for yield.

There is increasing urban encroachment around the research farm. There is a resident population of at least four deer in the vicinity of the farm. These deer have not caused significant damage in the past, but are being forced by urban encroachment onto the farm. Trapping or hunting are not options. Repellant sprays might work for a time, but would require repeated applications during winter, no guarantee that they will work over time and I

am not aware of any that are labeled for use on food crops. Fencing is the only remaining option, although expensive.

The ideal solution would be to fence the entire research farm, but this would be very expensive. A less expensive alternative would be to designate specific areas from which deer can be excluded. Two areas have been established for replicated yield plots at WSU Puyallup Farm 5. One area is 500 feet x 275 feet. This area includes the 1997 replicated planting that has been removed and the 1998 replicated planting (the one that had severe deer damage) and the 1999 planting. This area is proposed to be fenced. The second area (where the 2000 replicated planting and the 2001 replicated planting will be established) is smaller and there has not been evidence of deer damage. Fencing is not proposed for this area (however, deer damage had not been noted in replicated plantings previously). Minor deer browsing has been observed in some seedling fields. Since quantitative data is not collected from the seedling fields, deer fencing is not proposed for the seedling fields.

A 10-foot black plastic deer fence with a 12-foot wide gate is proposed to exclude deer from the 500 feet x 275 feet area. This area should be large enough for three replicated plantings (depending on the number of selections).

Anticipated Benefits:
Fencing three acres for deer exclusion will allow the collection of quantitative data for raspberry selections. This will allow accurate assessment of performance of selections.

Budget:

	2001-2002
03 Service and Supplies	$7,100
Total	**$7,100**

This is the cost of materials for 1,540 feet of 10 foot black plastic deer fence, 14 foot 4-5" rounds set in soil or gravel, and a 12 foot wide gate, including installation and tax.

Project No.: New

Title: Optimizing nitrogen use in 'Meeker' red raspberry

Year initiated: 2001 Current year: 2000/2001 Terminating year: 2003

Personnel: **Co-Principal Investigators**
Stephen F. Klauer and **Chuhe Chen**, Research Associates, WSU Vancouver REU
Bernadine Strik, Professor, Horticulture, OSU
Tim Righetti, Professor, Horticulture, OSU

Cooperators: **Peter R. Bristow**, Associate Plant Pathologist, WSU Puyallup REC
Craig Cogger, Associate Soil Scientist, WSU Puyallup REC
Hannah G. Rempel, Graduate Student, Dept. of Horticulture, OSU

Justification: Optimal fertilization timing and quantity remain common questions in raspberry. These practices vary widely, especially with regard to the total amount of nitrogen (N) applied per year. N is usually applied in granular form in the spring, and then supplemented by most growers with foliar applications throughout the season, often in conjunction with fungicides. A small percentage of the total industry fertigates. Some growers base their applications on soil/tissue analysis; others do it in an "intuitive" manner by looking at the plants. Amounts applied will vary greatly depending upon soil type and rainfall. Pacific Northwest Extension Bulletin 176 recommends granular rates of 40-100 lb. N/acre usually applied as a single application in the spring. These recommendations are based on research conducted some time ago with varieties other than Meeker and are now being questioned by growers. N rates need to be reevaluated with Meeker to determine what levels are optimal for yield and fruit quality under northern WA climate and soil conditions. In addition, a better understanding of fertility needs will arm growers with knowledge that can be used to better address groundwater contamination questions, should they arise.

Strik et al. from OSU have just completed a study of nitrogen uptake and partitioning in 'Kotata' trailing blackberry using labeled nitrogen (^{15}N). The label is in the form of a safe isotope ^{15}N that the plant takes up and utilizes just like the more common form of N. It acts as a marker so that it can be tracked both in the soil and in the plant after application as a fertilizer. Very useful information was obtained regarding when and how much to fertilize trailing blackberry under an alternate year (AY) production system. This work is very expensive because extensive sampling of tissue and soil must be done and analyzed with a special instrument (a mass spectrometer). The labeled fertilizer is also expensive.

Strik and Righetti have gotten substantial funding to do a similar study in red raspberry from the Oregon Raspberry and Blackberry Commission (ORBC) and from the Northwest Center for Small Fruits Research (NCSFR). The NCSFR funding will cover the cost of a graduate student to do most of the OSU work. Additional money (primarily

from the ORBC) has been provided to cover some of the costs of the fertilizer, sample analysis and miscellaneous other expenses. This will be an in-depth study using 'Meeker' red raspberry plots at the North Willamette Research and Extension Center (NW. Plots will be treated with 80 or 40 lb labeled N as a single application at budbreak, 80 lb split into two applications of 40 lb at budbreak (unlabeled N) and early fruit set (labeled N) or with no N at all. Plants (including roots) will be destructively sampled on six dates spanning the time from one month after initial fertilization at budbreak through plant development and harvest, until dormancy (December). Plants will receive only unlabeled N fertilizer the second season so that labeled N, stored from the previous season, can be tracked. Cycling of N in the soil will also be studied, because in the Pacific Northwest, naturally fertile soils may release (mineralize) a large amount of N each year. These studies should provide us with valuable information that can help us determine when and how much nitrogen should be applied in raspberry.

However, there are many variables that may effect how much fertilizer a planting needs. These may include the history/age of the field, the climate (temperature and rainfall), the soil type, the organic content, the soil pH and overall mineral balance, etc. Microbial activity likely varies based on many of these things and can effect uptake. Therefore it is often difficult to generalize N studies from one location to another.

In conjunction with OSU, we have a unique opportunity to explore long unanswered questions related to amount and timing of nitrogen application. We propose here to do smaller-scale companion studies at research sites in SW and NW Washington. With a relatively small investment from the WRRC, we can compare our results to the in-depth study to see how data compare. If we get similar N partitioning and mobilization patterns as those observed at NWREC, then we might be more comfortable in generalizing recommendations to other sites. If we don't, that will still be very valuable information and can lead to further work. This work can give us information that Washington growers have wanted and needed for some time.

Objectives:

Study nitrogen partitioning and cycling in red raspberry at two sites in Washington in context of the larger OSU nitrogen use and management study.

Procedures: Two sites in Washington have been selected for the study, one in Skagit County, and the other at WSUV REU in Clark County. Using seed money from the ORBC, an initial application of labeled fertilizer has already been applied at each site. This allowed us to get a start on the stored reserves part of the study to observe in 2001.

At both the Skagit, and the WSUVREU sites, we will monitor and destructively harvest three replications of the following three treatments each year:

1) An unfertilized control that was fertilized with unlabeled N (40 lb applied at budbreak and 40 lb applied at early fruit set) the previous year. This treatment was already applied in 2000.

2) Plots fertilized with labeled N applied at budbreak (40 lb unlabeled N) and at early fruit set (40 lb labeled N).
3) Plots fertilized with unlabeled N during the year of evaluation, but fertilized with labeled N the previous year as described in treatment 2 (This treatment was already applied in 2000).

Plots are 12 feet long. Three single plant replicates in each year will be excavated on one date. Plants will be partitioned into roots (portion) crown, primocanes, primocane leaves, floricanes, fruiting laterals and fruit if present; dried to a constant dry weight and analyzed for amount of total N and ^{15}N present. Estimated yield potential will be calculated.

At the WSUVREU site, a study of nitrogen cycling in the soil will be compared to the OSU study. Treatments will be the same as above except just individual plants (instead of 12 foot plots) will be fertilized with a labeled N fertilizer that is easier to track in the soil. This fertilizer is more expensive, so only individual plants are used as replicates. A fourth treatment will be added: previously labeled canes will be cut out and chopped up after harvest and placed around the base of an unlabeled plant. This will help us gain experience in evaluating the N that gets incorporated into organic matter, it's long term availability to the plants, and how fast it disappears in later years. For these treatments, we will only sample the soil at different depths for N. Plant N levels will already be determined from the destructive sampling of the first set of treatments.

Leaf physiological characteristics will be analyzed approximately twice during the season, at peak assimilate demand and post harvest. Intact leaves will be measured with a "SPAD" portable chlorophyll meter during the season to determine if N differences are present.

Soil temperature will be monitored at each site using HOBOs. A soil scientist will evaluate soil type and conditions.

Anticipated Benefits and Information Transfer: Upon completion of OSU's two-year study at NWREC, we will know when red raspberry plants take up N, how N is partitioned in the plant, how much is remobilized from stored reserves in the spring and how soil mineralization of nitrogen should impact crop fertilization. We will know whether a single application of N or a split application is more efficient. The WSU part of the study proposed here should give us a good idea of how applicable the results from the OSU study are to Washington sites that vary in soil type and climate. This information is critical, if we are to make N recommendations across the Pacific Northwest. If partitioning patterns are similar, then we can be fairly comfortable about generalizing what we learn from the OSU study. If they are different, then the information is a good starting point for further work.
Information\Technology Transfer: This information will be disseminated at regional and national grower's meetings as well as through local, regional and national publications.

Budget:

Request for 2001:	
Temporary employees	**2,000**
Supplies and services (plant and soil analyses, labeled fertilizer)	**5,080**
Equipment (HOBOs)	**680**
Travel	**500**
Benefits (16% of 01)	**320**
Total	**$8,580**