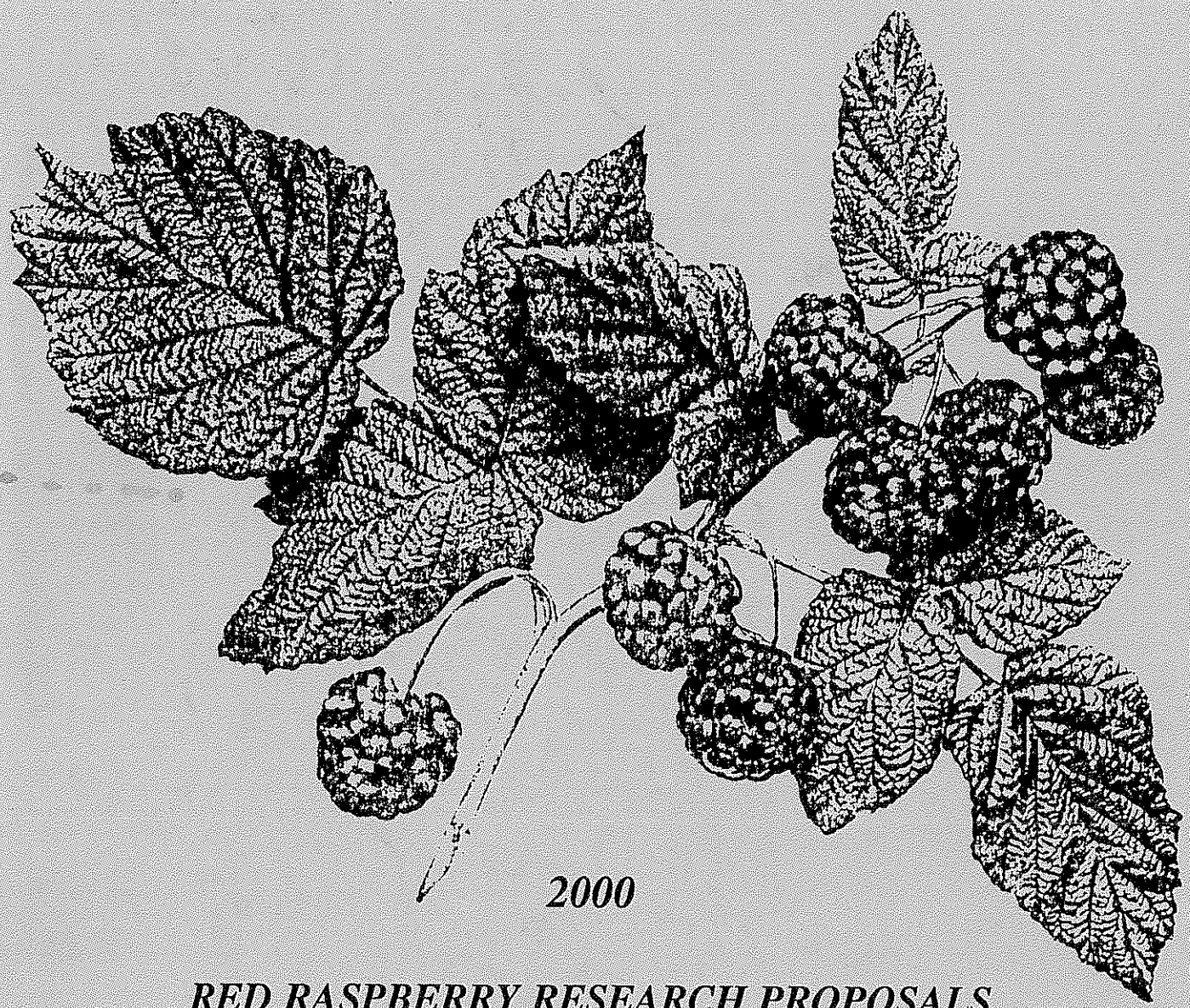

2000

RED RASPBERRY RESEARCH PROPOSALS

1999 PROGRESS REPORTS

to the

WASHINGTON STATE RED RASPBERRY COMMISSION

and

NORTHWEST RED RASPBERRY GROWERS ASSOCIATION

WASHINGTON RED RASPBERRY COMMISSION
BOARD OF DIRECTORS
1999-2000

Monte Maberry, President
816 Loomis Trail Road
Lynden, WA 98264
360/354-2094 office
FAX: 354-8182

Jerry Dobbins
1405 Goerig Road
Woodland, WA 98674
360/225-8556
FAX: 225-7764

Mary Beth Lang
Ag Trade Development
WA Dept. of Ag
P.O. Box 42560
Olympia, WA 98504-2560
360/902-1812
FAX: 902-2092

Merril Firestone, VP-Treasurer
12516 NW 29th Ave.
Vancouver, WA 98685
360/573-4638

Richard Sakuma
P.O. Box 427
Burlington, WA 98233
360/757-6611
FAX: 757-3936

Anne Seeger, Executive Director
Washington Red Raspberry Commission
1323 Lincoln St., #204
Bellingham, WA 98226
360/671-1437
FAX: 738-8069

Dan Petek, Marketing Director
Washington Red Raspberry Commission
1626 North Atlantic
Spokane, WA 99205
509/328-7307
FAX: 326-6175

Derrick Youngquist
16402 Jungquist Rd.
Mt. Vernon, WA 98273
360/424-7220
FAX: 424-7225

Arturo Flores
Graysmarsh Farm
6187 Woodcock Rd.
Sequim, WA 98382
360/683-5563
FAX: 683-6504

Tena Ondeck
2096 Halverstick Rd.
Lynden, WA 98264
360/988-6324

NORTHWEST RED RASPBERRY GROWERS ASSOCIATION
Paul LaCroix
2017 Continental Place #6
Mt. Vernon, WA 98273
360/424-7327

Lee Roy Kirk, President
P.O. Box 321
Puyallup, WA 98371

A:RaspComm.00/cp3/cm
11/99

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Summary
Budget Requests

On-Going Projects

Project No.	Short Title	Lead Scientist	Amount Requested
13C-3755-5641	Raspberry Breeding	Moore	$ 35,600
13C-3755-7641	Advanced Testing/Vancouver	Moore	7,000
13C-3755-8641	Advanced Testing/Mt. Vernon	Moore	7,000
13J-3543-4977	Orange Tortrix Control	Tanigoshi	3,480
13C-3555-5784	Yield Efficiency	Klauer	11,100
13C-3761-6718	Control of Phytophthora	Bristow	4,220
	Bushy Dwarf Resistance	Martin	12,000
	Cultivar Development for PNW	Kempler	7,000
13C-3761-3640	Gypsum to control Root Rot	Bristow	2,550

New Projects

Short Title	Lead Scientist	Amount Requested
Soil solarization	Bristow	$ 1,625
Red Rasp. Propagation Survey	Bristow	9,510
Raspberry Crown Borer Control	Heath	2,828
Tomato Ringspot Virus	Martin	4,750
Caneburning & Weed Control	Miller	13,600
Clay Colored Weevil	Tanigoshi	4,980
Control of Root Weevils	Tanigoshi	4,640
Integrated Research	Tanigoshi	9,777

A:Raspbk.00/cp3/cm

Project: 13C-3755-5641
Title: Red Raspberry Breeding, Genetics and Clone Evaluation
Personnel: Patrick P. Moore, Associate Horticulturist,
WSU Puyallup Research and Extension Center
Reporting Period: 1999

Accomplishments: In 1999, 74 crosses were made for cultivar development. Ten additional crosses were made between species hybrids and cultivars and open pollinated seed was collected from 13 species hybrids. About 3,500 seedlings were planted at Puyallup from 1998 crosses. Selections will be made among these seedlings in 2001 and 2002. A new replicated planting was established of 231 plots with 63 clones on raised beds treated with gypsum and Ridomil. Ninety-eight selections were made from seedlings planted in 1996 and 1997, 73 for cultivar development and 25 for breeding purposes. There were 40 selections in the 1996 planting with WSU 1020, WSU 1068, Kitsilano, and WSU 1069 being the best parents. There were 58 selections in the 1997 planting with 33 for cultivar development with Qualicum, WSU 1066, and WSU 984 being the best parents. Twenty-five selections were made of the species hybrids in the 1997 planting.

The 1996 replicated planting was harvested for the second time in 1999 (Tables 1 and 2). It was planted in an area with high levels of root rot, which resulted in missing plots and high variability. The three highest yielding clones were WSU 1068, WSU 1162 and WSU 1098. WSU 1162, WSU 1163, and WSU 1164 all were notable for high vigor and probably have a high level of root rot resistance. All three are from the cross of WSU 984 and Chief. In addition to the possible root rot resistance, WSU 1162 had high yields of medium size fruit and will be propagated for grower trial.

The 1997 replicated planting was harvested for the first time in 1999 (Table 3). WSU 1096, WSU 1161 and WSU 1098 had the highest yields. WSU 1096 is unacceptable because of weak laterals. WSU 1161 had a short harvest season and very erect growth. WSU 1161 was selected from the cross of Brandywine (a purple raspberry) and Chilliwack. Therefore it is ¼ black raspberry. Fruit will be frozen next summer for fruit evaluation. WSU 1098 had high yield in both the 1996 and the 1997 plantings. It produces very dark, highly flavored fruit.

Plants were propagated, planted in pots, grown outside and will be challenged for raspberry bushy dwarf virus resistance (RBDV). 403 plants were potted representing 140 clones to be challenged and 134 RBDV infected plants. Plants will be tested annually to determine resistance/susceptibility to RBDV.

Presentations:

January, 1999. Strawberry and Raspberry fruit display. Northwest Food Processors, Portland, OR.

July, 1998. Raspberry Field Day, Puyallup, WA.

Table 1. 1998-1999 yield of 1996 planted raspberries, Puyallup, WA

	Yield (t/a)		
	1999	1998	Total
WSU 1068	7.9 a	11.1 a	19.1 a
WSU 1162	7.9 a	10.7 a	18.6 ab
WSU 1098	8.0 a	9.5 a	17.6 a-c
WSU 1067	4.7 ab	11.5 a	16.2 a-d
WSU 1024	5.3 ab	10.5 a	15.8 a-d
WSU 1082	5.8 ab	9.9 a	15.7 a-d
WSU 1164	5.5 ab	8.8 a	14.3 a-d
WSU 1159	4.5 ab	7.9 a	12.4 a-d
WSU 1156	4.8 ab	7.6 a	12.4 a-d
Meeker*	4.4 ab	7.8 a	12.2 b-d
Comox*	3.0 b	8.5 a	11.5 cd
WSU 1097	3.8 ab	7.3 a	11.1 cd
WSU 1166*	4.2 ab	6.4 a	10.6 d
WSU 1099*	2.2 b	8.1 a	10.3 d
WSU 1163	4.1 ab	6.2 a	10.3 d
Tulameen*	1.3 b	8.7 a	10.1 d
WSU 1066*	1.8 b	8.2 a	10.0 d
Willamette	2.3 b	7.2 a	9.5 d
Average	4.5	8.7	13.2

Means of 3 plots of 3 hills.
* 3 plots harvested in 1998, only 2 plots harvested in 1999 as a result of root rot. Yield for unharvested plots was set to 0.0
Clones in bold have been distributed to growers for testing.

Table 2. 1999 harvest of 1996 planted raspberries, Puyallup, WA.

	Fruit Rot (%)	Fruit weight (g)	Fruit Firmness (g)	Harvest Season 5%	50%	95%	Length of season
Clones represented by 3 plots							
WSU 1068	2.1 a	4.3 ab	188 cd	6/27 de	7/10 c	7/24 bc	27 a
WSU 1162	3.0 a	3.1 c	160 d	7/5 ab	7/19 ab	8/2 a	28 a
WSU 1098	1.1 a	3.0 c	108 e	7/6 ab	7/16 b	7/28 ab	22 a
WSU 1067	3.3 a	3.6 bc	173 d	7/7 ab	7/19 ab	8/2 a	26 a
WSU 1024	2.5 a	3.7 bc	259 a	7/11 a	7/22 a	8/2 a	23 a
WSU 1082	7.2 a	4.8 a	231 ab	7/3 bc	7/14 b	7/27 ab	24 a
WSU 1164	3.8 a	3.5 bc	112 e	7/5 ab	7/19 ab	7/31 a	26 a
WSU 1159	0.5 a	1.9 d	95 e	6/25 e	7/6 c	7/20 c	24 a
WSU 1156	3.1 a	3.5 bc	217 bc	7/7 ab	7/18 ab	7/29 ab	23 a
WSU 1097	0.4 a	3.2 c	109 e	7/1 b-d	7/15 b	7/27 ab	25 a
WSU 1163	1.0 a	3.0 c	105 e	7/3 bc	7/15 b	7/27 ab	23 a
Willamette	0.4 a	2.7 cd	183 cd	6/28 c-e	7/9 c	7/20 c	22 a
Clones represented by 2 plots							
Meeker	2.1 a	3.3 a	172 ab	7/11 a	7/22 a	8/1 a	22 a
Comox	1.5 a	2.9 a	239 a	7/8 a	7/18 a	7/29 a	21 a
WSU 1166	3.1 a	2.3 a	76 c	6/30 a	7/15 a	7/27 a	28 a
WSU 1099	0.6 a	3.0 a	128 bc	7/5 a	7/15 a	7/28 a	23 a
Tulameen	0.7 a	3.6 a	166 ab	7/7 a	7/17 a	7/28 a	21 a
WSU 1066	0.3 a	3.4 a	189 ab	7/7 a	7/15 a	7/26 a	19 a
Average	2.1	3.3	162	7/4	7/15	7/28	24

Table 3. 1999 harvest of 1997 planted raspberries, Puyallup, WA

	Yield (t/a)	Fruit rot (%)	Fruit weight (g	Firmness (g)	Harvest season 5%	50%	95%	Length of season
Clones represented by 3 plots								
WSU 1096	9.2 a	5.4 d-f	3.2 g-l	155 hi	7/1 f-k	7/18 e-h	8/2 c-e	32 ab
WSU 1161	8.7 ab	6.6 c-f	3.9 c-f	167 f-h	7/8 b-e	7/18 e-h	7/30 d-h	21 h
WSU 1098	8.1 a-c	3.6 d-f	2.8 l-n	101 lm	7/8 b-e	7/18 e-h	8/2 c-e	25 d-h
WSU 1097	7.1 a-d	2.3 f	2.9 j-m	106 kl	7/4 c-i	7/18 e-h	8/2 c-e	29 a-f
TULAMEEN	7.0 a-d	7.7 c-f	4.3 b-d	180 e-h	7/7 b-f	7/20 d-f	8/5 bc	29 a-f
WSU 1099	7.0 a-d	2.9 ef	3.9 c-e	152 hi	7/8 b-e	7/20 d-f	8/3 b-d	26 c-h
WILLAMETTE	6.1 b-e	2.9 ef	3.3 f-l	184 d-g	6/29 h-l	7/15 h-l	7/28 e-i	30 a-e
WSU 1024	6.1 b-e	5.4 d-f	3.8 d-h	214 bc	7/10 bc	7/25 b	8/5 a-c	26 b-h
WSU 1067	6.1 b-e	9.7 cd	3.6 e-i	159 g-i	7/8 b-e	7/21 c-e	8/1 c-f	24 d-h
WSU 1186	5.9 b-f	7.7 c-f	4.3 b-d	226 ab	7/7 b-f	7/24 bc	8/7 ab	31 a-c
WSU 1068	5.8 c-f	6.0 c-f	3.8 c-g	193 c-f	6/26 kl	7/8 p	7/22 jk	27 a-h
BC 89-33-84	5.6 c-f	5.5 d-f	3.6 e-i	241 a	6/30 g-l	7/19 e-h	8/1 c-f	32 a
ORUS 1025-10	5.6 c-g	3.6 d-f	4.3 b-d	179 e-h	7/16 a	7/31 a	8/9 a	25 d-h
WSU 1182	5.4 c-h	6.2 c-f	3.2 i-l	112 j-l	7/2 f-k	7/16 g-k	7/30 d-g	29 a-g
Glen Magna	5.4 c-h	4.5 d-f	5.0 a	189 c-f	7/8 b-e	7/22 b-d	8/1 c-f	24 d-h
WSU 1090	5.3 c-h	21.4 a	4.7 ab	211 b-d	7/9 b-d	7/23 b-d	8/4 bc	26 b-h
WSU 1183	5.3 c-h	6.7 c-f	3.5 e-j	120 j-l	7/1 f-l	7/14 i-m	7/24 i-k	24 f-h
WSU 1193	5.0 d-l	5.4 d-f	3.4 e-k	223 ab	6/28 i-l	7/13 k-o	7/28 f-i	30 a-e
MEEKER	5.0 d-l	3.6 d-f	3.3 f-l	180 e-h	6/30 g-l	7/18 e-h	7/30 d-g	30 a-d
ORUS 1072-11	4.9 d-l	2.8 ef	3.2 g-l	205 b-e	7/5 c-h	7/16 g-j	7/28 f-i	23 gh
ORUS 870R-12	4.8 d-l	6.3 c-f	3.6 e-i	209 b-d	6/25 l	7/11 n-p	7/22 jk	28 a-g
WSU 1185	3.5 e-j	3.1 ef	3.1 i-l	157 g-i	7/1 f-l	7/12 l-o	7/22 jk	22 h
WSU 1196	3.5 e-j	12.2 bc	3.5 e-j	154 hi	7/1 f-k	7/14 j-n	7/25 h-k	24 d-h
WSU 1194	3.4 e-j	21.0 a	3.4 e-k	248 a	6/27 j-l	7/12 m-o	7/23 jk	25 c-h
WSU 1184	3.0 f-j	4.4 d-f	2.9 k-m	138 ij	7/3 d-j	7/18 e-h	7/28 f-i	24 d-h
WSU 1082	3.0 f-j	16.6 ab	4.3 bc	192 c-f	7/3 e-j	7/16 g-k	7/24 i-k	22 h
WSU 1187	2.6 g-j	5.6 d-f	2.3 n	78 m	6/30 g-l	7/12 l-o	7/21 k	21 h
WSU 1199	2.5 h-j	9.3 c-e	2.6 m-n	132 i-k	6/28 i-l	7/10 op	7/21 k	23 f-h
Glen Rosa	2.3 ij	6.9 c-f	3.1 i-l	178 e-h	7/5 c-g	7/17 f-i	7/27 g-j	22 h
BC 87-5-1	0.7 j	10.1 cd	3.2 h-l	169 f-h	7/12 ab	7/19 e-g	7/26 g-k	14 i
Clones represented by 2 plots								
ORUS 1149-1	7.8 a	5.9 a	3.9 a	178 bc	6/27 c	7/15 bc	7/27 a	31 a
WSU 1190	6.4 a	2.9 a	3.4 a	136 d	7/12 a	7/26 a	8/6 a	26 a
BC 90-4-48	4.8 a	5.1 a	3.2 a	150 cd	7/9 ab	7/18 ab	7/29 a	20 a
Mirage	4.7 a	13.0 a	3.9 a	212 b	7/5 b	7/19 ab	7/31 a	26 a
WSU 1200	4.1 a	7.9 a	3.6 a	152 cd	7/3 b	7/15 bc	7/27 a	24 a
WSU 1195	3.7 a	7.5 a	3.5 a	191 bc	6/26 c	7/8 c	7/23 a	27 a
Glen Shee	3.3 a	11.8 a	4.8 a	270 a	7/9 ab	7/25 a	8/5 a	27 a
Average	5.1	7.2	3.6	173	1/4	1/17	1/29	26

Plots consist of 3 hills.

PROJECT: 13C-3755-5641

TITLE: Red Raspberry Breeding, Genetics and Clone Evaluation

YEAR INITIATED:1996
CURRENT YEAR:2000
TERMINATING YEAR:2000

PERSONNEL: Patrick P. Moore, Associate Horticulturist,
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, fruit color, and drupelet number 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. 74 crosses were made for cultivar development in 1999. 10 crosses were also made with species hybrids and open pollinated seed collected from 13 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 2002 and 2003.

3. Selections will be made among the seedlings planted in 1997 and 1998. 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 1999 (73 selections) will be propagated for testing in three replications of three hill plots and compared to standard cultivars. 25 other selections made in 1999 will be used for breeding only. 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 2002 and 2003. 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 1997 will be harvested for the second time and the planting established in 1998 will be harvested for the first time in 2000.

7. Plants will be multiplied in tissue culture and propagated for testing at other locations and grower trials. WSU 1112, WSU 1161 and WSU 1162 are currently being propagated 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.

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 0.25 of an Agricultural Research Technician I. The remaining 0.35 of the cost of the position will be funded for 2000-2001 by other commissions. A Lab. Tech. I will work 0.1 of the time with the 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 and travel to research plots and to grower meetings to present results of research.

Budget:	**1999-2000**	**2000-2001**
00 Salaries		
Agr. Res. Tech. 0.25 FTE	$8,305	$8,133
Lab Tech 0.10 FTE	0	2,847
01 Timeslip Labor	12,500	12,500
03 Service and Supplies	5,539	5,565
04 Travel	500	500
07 Benefits		
Agr. Res. Tech.	3,156	3,172
Lab Tech	0	1,059
Timeslip	2,000	2,400
Total	**$32,000**	**$35,600**

Current & Pending Support

Name (List PI #1 first)	Supporting Agency & Project #	Total $ Amount	Effective and Expiration Dates	% of Time	Title of Project
Moore, P.P.	Current: Oregon Raspberry and Blackberry Com.	$2,000	1999-2000		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, Associate Horticulturist, WSU Puyallup
Steve Klauer, Research Associate, WSU Vancouver

Reporting Period: 1999

Accomplishments:
The raspberry planting established at WSU Vancouver in 1996 on raised beds was harvested for the first time in 1999 (Table 1). WSU 1099, Meeker, WSU 1082 and WSU 1067 had the highest yields. In 1997, plants of several selections were available for grower trials. Some plants were planted and machine harvested at WSU Vancouver in unreplicated plots (Table 2). WSU 1099 had the highest yields in this planting also. More detailed observations will be made in 2000.

A new replicated planting was established in 1999 of 12 clones including WSU 1068, WSU 1090, WSU 1098, 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.

Table 1. 1999 harvest of 1996 planted raspberries at Vancouver, WA.

Clone	Yield (t/a)	Fruit Rot (%)	Fruit Weight (g)	Harvest Season 5%	50%	95%	Length of Season
WSU 1099	7.4 a	2.6 a	3.70 ab	7/7 ab	7/18 a-d	8/5 ab	29 a
Meeker	7.1 a	3.2 a	2.90 cd	7/8 ab	7/23 a	8/6 a	29 a
WSU 1082[2]	6.8	8.3	4.17	7/4	7/15	7/29	26
WSU 1067	6.0 a	5.7 a	3.15 a-d	7/5 ab	7/19 a-c	8/3 a-c	29 a
Tulameen	5.9 a	2.2 a	3.89 a	7/8 ab	7/19 a-c	8/5 ab	28 a
NY-7 (Encore)	5.3 a	1.5 a	3.58 a-c	7/5 ab	7/18 a-d	8/2 a-c	28 a
ORUS 958-10[2]	4.8	1.3	3.48	7/12	7/26	8/7	26
WSU 1024	4.5 a	6.7 a	3.04 b-d	7/6 ab	7/19 a-c	8/2 a-c	27 a
WSU 1097	3.9 a	6.5 a	3.16 a-d	6/29 c	7/12 d	7/30 a-c	31 a
BC 86-6-15	3.8 a	10.2 a	3.06 b-d	7/2 bc	7/15 cd	7/29 bc	27 a
WSU 1096	3.2 a	8.4 a	3.05 b-d	7/2 bc	7/15 b-d	8/1 a-c	30 a
Willamette	3.2 a	6.2 a	2.59 d	7/2 bc	7/14 cd	7/26 c	24 a
Comox	3.0 a	7.8 a	3.42 a-c	7/4 bc	7/18 a-d	8/1 a-c	28 a
ORUS 2078	2.5 a	3.1 a	3.30 a-d	7/11 a	7/22 ab	8/5 ab	26 a
Malahat	2.4 a	7.3 a	3.49 a-c	7/3 bc	7/16 b-d	7/29 bc	26 a
Average	4.7	5.4	3.33	7/5	7/18	8/2	28

Values are the means of three 3 plant plots except for clones indentified by [2] which were present in only two plots.

Table 2. 1999 machine harvest of 1996 planted raspberries
Vancouver, WA

Clone	Yield (kg/hill)
WSU 1099	2.62
WSU 1090	2.42
WSU 1066	2.42
WSU 1024	2.37
WSU 1096	2.26
WSU 1098	1.77
WSU 1067	1.75
WSU 1082	1.65
WSU 1024	1.39

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

PERSONNEL: Patrick P. Moore, Associate Horticulturist, WSU Puyallup;
J. Scott Cameron, Associate Horticulturist, Chuhe Chen and Stephen F. Klauer, Research Associates, WSU Vancouver.

YEAR INITIATED: 1996
CURRENT YEAR: 2000
TERMINATING YEAR: 2000

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.

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 17 raspberry clones was established at WSU Vancouver in 1996. This planting will need to be maintained and the plants trained. It will be harvested for yield, fruit weight, fruit rot, and harvest season in 2000.

2. The non-replicated raspberry planting established in 1997 will be machine harvested in 2000. In addition to yield, observations will be made on ease of harvest and damage by the harvester.

3. 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. Promising clones that were included in this planting are WSU 1068, WSU 1090, WSU 1098 and WSU 1112.This planting will need to be maintained and the plants trained. It will be harvested for yield in 2001 and 2002.

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. 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:	**1999-2000**	**2000-2001**
01 Timeslip Labor	4,500	4,750
03 Service and Supplies	1,380	1,340
04 Travel	150	150
07 Benefits	720	720
Total	**$6,750**	**$7,000**

Project: 13C-3755-8641

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

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

Reporting Period: 1999

Accomplishments:
A planting of 18 clones was established in 1998 including 2 BC selections, 2 ORUS selections and 9 WSU selections. This planting was maintained in 1999 and harvest data will be collected in 2000. The planting established in 1996 was removed.

In the 1999 proposal, plans were to harvest the 1996 planting for a second time in 1999. The proposal was only partially funded. The Chair of the Washington Red Raspberry Commission Research Committee was consulted about expectations with this level of funding. After discussion with the Chair of the Research Committee, the plots in the 1998 planting were maintained, and the 1996 planting removed.

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, Associate Horticulturist, WSU Puyallup; Gary Moulton, Scientific Assistant, WSU Mt. Vernon.

YEAR INITIATED: 1996
CURRENT YEAR: 2000
TERMINATING YEAR: 2000

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 new replicated planting of 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 will

be harvested for yield in 2000 and 2001.

2. A new replicated planting of raspberry selections will be established. It will include selections that have performed well at WSU Puyallup, but have not been adequately tested at WSU Mt. Vernon.

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:	**1998-99**	**1999-2000**
00 Salaries		
Agr. Res. Tech 0.10 FTE	$2,785	$2,894
01 Timeslip Labor	2,000	2,000
03 Service and Supplies	576	680
04 Travel	150	150
07 Benefits		
Agr. Res. Tech.	919	956
Timeslip	320	320
Total	**$6,750**	**$7,000**
	($3,000 funded)	

Current & Pending Support

Name (List PI #1 first)	Supporting Agency & Project #	Total $ Amount	Effective and Expiration Dates	% of Time	Title of Project
Moore, P.P.	Pending: Northwest Ag. Res. Foundation	$ 7,800	2000-2001		Evaluation of small fruits at WSU Mount Vernon

PROJECT NO: 13C-3543-5967

TITLE: A New Model for Cooperative, Integrated Entomological, Plant Pathology and Horticultural Research in Northern Washington

PERSONNEL: ***Co-Principal Investigators***
Lynell K. Tanigoshi, Associate Entomologist, WSU Vancouver REU
Chuhe Chen, Stephen F. Klauer, Research Associates, WSU Vancouver REU
Peter P. Bristow, Associate Plant Pathologist, WSU Puyallup REC
J. Scott Cameron, Director & Assistant Dean, WSU Vancouver REU

COOPERATORS:
Craig MacConnell, Chair, Whatcom County WSU Coop. Extension
Arthur L. Antonelli, Extension Entomologist, WSU Puyallup REC
Malika Bounfour, Ph.D. Student, Entomology, WSU Vancouver REU

REPORTING PERIOD: 1999 (Terminal report)

ACCOMPLISHMENTS:
The innovative model for a satellite facility, initiated in 1996 in northern Washington, has continued to gain support from the red raspberry industry and to gain new partnerships. This model proved flexible and cost effective in bringing together federal, state, and industry resources. This base of support was used to leverage additional resources to enhance red raspberry research activities throughout western Washington. We unanimously agree that enhanced grower to researcher access in the northern region has forged a partnership with clear benefits to the red raspberry industry and Washington State University during the past four years. This collective spirit has already accelerated mutual discoveries of sensible chemical and biological solutions to contemporary horticulture and pest management problems. The project has broadened the industry's knowledge base and understanding of IPM strategies to help achieve cost-effective and environmentally sound control of pests.

RESULTS:

Entomology
Biological Control of Spider Mite Complex: The two spotted spider mite (TSSM), *Tetranychus urticae* Koch and yellow spider mite (YSM), *Eotetranychus carpini borealis* (Ewing) are foliar feeding pests (phytophages) of red raspberry, *Rubus idaeus L.* and are preyed upon by the phytoseiid mite, *Neoseiulus fallacis*

(Garman). Field studies conducted in Skagit and Whatcom counties in 1995-1997 showed that the two spider mite species and the predator are common in red raspberry fields. The climatic requirement for each species plays a major role in setting time of emergence from dormancy for the host plant, and predator. Laboratory studies on temperature-dependent developmental rates for the two phytophages were completed and showed that developmental thresholds were 10.5°C and 2.3°C for TSSM and YSM respectively. Reported developmental threshold for *N. fallacis* was 10.3 °C. When the TSSM and YSM overlap in space and time, interspecific competition and predator-mediated "apparent competition" are probably setting the dynamics occurring in mid-season (July-August). At the end of the season (September), climatic conditions are cooler and favorable for YSM when TSSM enters diapause. Laboratory and greenhouse experiments confirmed that interspecific competition is probably the most important interaction when the two species occur on the same leaf. The predator exhibited numerical and functional responses to TSSM. However, predatory activity occurs after the canes have undergone spider mite feeding damage. Efficacy of *N. fallacis* could be enhanced by introducing a phytoseiid species that is tolerant to environmental conditions prevalent during the period of April to June when the YSM is active and escapes predation from *N. fallacis*. Red raspberry plants show a rapid systemic response to spider mite feeding. Host plant-mediated competition is not a major factor in determining the population dynamics of the two spider mites species. Over a two-week period, an immune-like response developed to previous feeding from conspecifics rather than from competitors.

Control and Management of Root Weevils: Seasonal root weevil trials in red raspberry and strawberry indicated that chlorphyapyr (Alert) and fipronil (Regent) performed as well as bifenthrin (Brigade) for 2-3 weeks posttreatment. A pesticide clearance request was submitted to IR-4 for Alert in 1996 that was fully supported by American Cyanamid. However, its registration on small fruit is unlikely as EPA did not grant full registration to the manufacturer fur use on cotton due to its reproductive toxicity to birds. Rhone-Poulenc will not consider Regent because their risk cup has been exceeded for agricultural commodities. We supported a SLN for Gowan cryolite bait for root weevil control on small fruits. Further research is required to gain better knowledge on how to best apply and time this compound. We obtained another renewal (7th) for the Section 18 emergency exemption for Brigade. We expect a tolerance petition for Brigade will be submitted to EPA before the end of 1999. Brigade continues to look excellent as a weevilcide at its recommended rate when applied as either a basal or an over-the-row application.

Control and Management of the Clay Colored Weevil: Field awareness of their presence began in 1996, with their emergence in mid-March and early April. Feeding on fruiting cane buds was observed during subfreezing temperatures in Whatcom and Skagit counties in early spring. Basal application of Brigade as well as full canopy sprays with Brigade and Alert provided excellent initial knockdown of clay colored weevils and sustained control 14 days after treatment. Although the initial control with full canopy applications of Guthion and fipronil were marginal both materials performed well 14 days after treatment. Basal applications of Alert and fipronil as well as the full canopy Asana provided less than desirable control. The single application of Cryolite reduced clay weevil populations by 25%, 3 days after treatment, 40%, 7 days after treatment, and 45%, 14 days after treatment. This level of control was unacceptable given the potential impact of continued feeding on yield. For this reason, the grower chose to apply a basal Brigade in late April. Cryolite performance may have been compromised due to a day-length and a light but steady rain five days after the treatment was applied. Only two currently registered insecticides (Brigade, Guthion) provided adequate control, and due to the faster knockdown, Brigade applied to the lower 4 feet is the preferred tactic.

As was observed in 1998, clay colored weevils have two summertime egg-laying periods. During 1999, they initially laid eggs from early May through early June. This is followed by a non-reproductive period for three months and then the onset of egg laying again in mid-September through mid-October. As of September 20, 1999, the most productive weevil produced 87 eggs and the least productive produced none. Average production for this period was 46 eggs per weevil. Of the thirty original specimens collected for this study, mortality through September 20 was limited to one specimen that died on August 30. These data, in combination with timing at emerging bud break and small fruiting lateral development were used to time a clay colored weevil application prior to egg laying and irreparable fruit and foliage damage.

Plant Pathology

Research on diseases was incorporated into the overall program of the Lynden 'satellite' facility beginning in 1997.

1997:

- Determined when the spur blight fungus infects leaves on fruiting canes and when fungicide protection was needed to control infection on leaves of both fruiting canes and primocanes.
- Demonstrated that spur blight on leaves of fruiting canes can lead to early defoliation on reduced yield.

- Showed that two fungicides (Captan and Rovral) used for fruit rot control were also effective against the spur blight disease.
- Evaluated different fungicides, including the timing of liquid lime sulfur, for control of yellow rust.
- Assessed the importance of inoculum of the yellow rust fungus that overwinters on leaves trapped between canes where they are tied into bundles at the top trellis wire on disease initiation in the spring.

1998:

- Monitored the production of the wind dispersed spore stage of the spur blight fungus and determined that fungicides applied in the spring had no impact on spore production.
- Assessed fruit and cane diseases at three sites where a traditional pest control program was compared with an IPM program designed specifically for each site.
- Documented that resistance to currently registered fungicides used to control the fruit rot fungus *Botrytis cinerea* was widespread in both Skagit and Whatcom Counties.
- Secured a Section 18 emergency exemption for Orbit to control yellow rust disease.

1999:

- Again assessed fruit and cane diseases at three sites comparing Traditional and IPM pest management programs.
- Evaluated new and current fungicides for control of gray mold fruit rot. (Plots treated with Switch or Elevate had the highest yields and lowest incidence of fruit rot. These two fungicides also reduced cane botrytis and spur blight.)
- Found that Captan and one experimental compound increased spider mite damage on fruiting cane leaves when compared with untreated plants or those treated with other fungicides.
- Showed that adding foliar nutrients to fungicide sprays applied for control of fruit rot did not increase lateral length or the incidence of fruit rot.
- Evaluated the impact of trellis design and cane tying method on fruit and cane diseases (data from this experiment have not been summarized yet).
- Obtained a renewal of the Section 18 emergency exemption for Orbit to control yellow rust.
- Secured a Section 18 emergency exemption for Switch to control gray mold fruit rot.

Horticulture:

Split Trellis. Over the last four years we have compared the performance of the split vs conventional trellis in northern and southern Washington. With the split

trellis (ST), canes are trained to two top wires separated by various widths on crossarms mounted on field posts. This creates a "V" or "Y" shaped canopy that is more open at the top. With the conventional trellis (CT), canes are trained to a single topwire, resulting in a more closed rectangular shaped canopy. Numerous data were collected starting in 1996 and continuing through 1999. These included estimated yield potential, actual machine and hand-picked yield when possible, canopy and primocane measurements, yield components, above ground biomass partitioning, nitrogen analysis of leaf tissue, canopy light interception, leaf tissue for anatomical study and numerous physiological parameters including photosynthesis measurements, fluorescence, chlorophyll content and 4th derivative spectra. Data were collected from one trial in Lynden in 1996, and expanded to include numerous trials/sites over the next four years. With the split trellis, light penetration is increased within the canopy early in the season and this results in a large increase in canopy growth with increased numbers of leaves, laterals and fruit per cane, especially in the upper parts of the canopy. In all years, leaf physiological measurements were not 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, and hence its ability to increase yields. This should also help to increase the overall carbohydrate pool of the plant and thus crop sustainability. The most significant finding is that estimated yield potential has consistently been 20-60% greater for the ST compared to the CT. The difficulty has been harvesting the extra fruit using machines currently used by the industry. In 1997, Rolf Haugen achieved a 33% increase for the ST over the first six machine harvests before he stopped taking data due to fruit rot. On the Jerry Dobbins Farm near Woodland, there was a 20% increase in yield for handpicked plots on a 27-inch ST. In 1998, actual yields were 10-13% greater for ST in 4 of 6 trials, 2 of which were machine-picked, but yield was reduced by lateral damage and premature harvest of green fruit. This year, we had a breakthrough at the trial site on the Randy Honcoop Farm in Lynden. Littau Harvester suggested simple adjustments to their machine that, where correctly implemented, minimized these problems, resulting in an almost 20% increase in yield for the 20 inch ST. Damage to laterals was minimized by spreading the picking heads early in the season, and then moving them closer every three harvests as laterals toughened. Premature pick of green fruit was controlled by reducing beater speed RPMs with the turn of a dial. This is very significant because we have now reached a level of yield increase where increased profit will substantially offset costs attributed to increased labor for installing,

tying and pruning a split trellis. Materials and methods of installation of the split trellis varied between sites, but costs have been roughly estimated.

For example: Randy Honcoop's estimate of trellis costs per acre.

Materials and labor:
$160 for angle iron crossarms
32 labor to install
60 for additional wire
Total $252 per acre one-time installation fee for life of the planting.

Pruning/tying:
$600-715/yr (170% of CT costs)

Small additional costs may be needed to install heavier end posts to support the heavier canopy of the ST. Estimates of increased tying and pruning costs vary among growers, but are likely somewhere between 50-100% more for ST. This year actual yields for ST vs CT tied over canes were 7.5 vs 6.3 tons/acre respectively on the Honcoop Farm.

Assuming a hypothetical price of $.50/lb, ST net profit advantage over the CT would be $683/acre for the installation year, and $935/acre for the following years. For 100 acres: ST advantage is $68,300/year one and $93,500/each additional year.

A similar comparison between a 5 ton yield/acre (CT) vs a 6 ton yield/acre (ST) nets 16% more dollars/acre/yr for ST after the first year installation costs have been applied.

These estimates are rough and assume that yields are sustainable within the split trellis. All data thus far show that ST yields are sustainable. These estimates haven't included other costs of maintenance including fertilization or possibly increased pesticide use, if necessary, in the larger canopy. So far data do not support a need for more fertilization, and in fact, less might be better to reduce the large canopy size of ST and lessen potential impact on groundwater contamination. Numerous other environmental/pest/disease variables also may come into play and continue to be studied within the split trellis system. So far, no appreciable differences have been found in pest or disease variables within the trellis, but these have been difficult to assess when pesticides and fungicides are sprayed on both treatments.

While these data are very promising, further testing of this system is needed to study these variables. There is also grower interest in determining if similar yield

increases can be achieved with narrower ST widths. Our data thus far indicate that some yield advantage is lost with each decrease in width. Widths less than 17 inches showed no yield benefit. Data this year from the Honcoop Farm showed there is significant loss of fruit in the middle of the row with ST. Fine-tuning of timing and degree of machine adjustments may be able to capture some of this fruit and recoup even greater yields. A comparison of horizontal vs. vertical shaking heads and their relationship to yield would also be useful.

Winter Injury. Two sets of field experiments have been conducted in Lynden, Washington to evaluate cold damage to red raspberry "Meeker' from 1996-1999. Temperature and moisture HOBOs were set up in the check and cold damaged treatments to record the air and soil temperatures and air moisture. Cold injury caused significantly higher bud damage in all four years, though the yield losses were severe only during the 1995-1996 winter and moderate in the last winter. The large compensatory ability of raspberry makes yield loss due to cold injury alone in this area mild or insignificant in most years. The fruit yield of the cold injury plots recovered during 1996-1997 mild winter, and exceeded the check in 1997-1998. Cold injury reduced berry yield mainly through a steep drop in lateral number / cane due to bud damage and cane die back. Cold damage also caused an increase in secondary laterals. Secondary laterals had fewer berries per lateral and are less productive because of shortened time for flower initiation. Severely cold injured fruiting canes had lower gas exchange rates during fruit development of the injury season, and higher photosynthetic rates in the recovery years due to sink feedback control. Cold injury to the plants is mechanical in nature, and plants will fully recover if recurring stresses stop. On a few cold days, the HOBOs in the canopy recorded a lower daily low temperature in the cold damaged area than in the check area, which is located closer to a tree belt (windbreak). It shows cold winds could play an important role in reducing air temperature at canopy level and might cause more damage to the plants. Planting windbreaks may be useful wherever plants seem susceptible to winter injury and drying winter wind exposure is a factor. No differences between the treatments were detected in leaf nitrogen content. When cold injury is exacerbated by infestations of clay-colored weevil (CCW) and spur blight, the combined damage to the buds and fruit yield could be devastating. We recorded 60% bud damage and 61% yield per plant loss in a field in Lynden last year. The combined damage was well above the compensatory ability of the raspberry plant, which resulted in not only lower lateral number /cane, but also lower fruit number / lateral and fruit weight. The spring bud damage by CCW left little time for the secondary laterals to initiate flowers. An integrated pest management system is highly recommended to avoid the cumulative damage to the buds and has special importance in the northern part of the state, where cold injury occurs frequently. A spotted pattern of severe bud

damage that often occurs in raspberry fields in that area, which most growers attribute to cold injury, is more likely a result of combined bud damage caused by pests and cold. A further study of the cumulative and interactive effects of pests and cold injury on bud damage of raspberry will be conducted in northwest WA.

Interdisciplinary Collaboration.

Farm-Scale Trials in 1998 and 1999 to Compare Efficacy and Economics of a Standard/Traditional Program vs Institutionally Derived Pest Management Tactics Within the Context of IPM:

Central to gaining grower acceptance of a more ecologically-based management program for red raspberry pests, three cooperating growers were part of the process in deciding which practices would be used in the IPM blocks on their respective farms during 1998 and 1999. The cooperators also provided dollar figures for inputs for the traditional blocks and collaborated with researchers to develop similar information for the IPM blocks. This joint interdisciplinary effort provided excellent applied research data along with economic outputs, which provided valid data to compare the short and long term feasibility of both strategies. The attached Table 1 compares the pesticide costs in the Traditional and IPM approaches for 1998 and 1999. It is evident from looking at this table that there is variation from one farm to the next and from year to year with both programs. The most consistent cost reduction associated with IPM was in fungicides in both years. This was due primarily to lengthening the interval between applications based upon weather conditions. This closer scrutiny usually resulted in a reduced number of applications and therefore lower cost. Insecticide costs were quite comparable across the board. The significantly higher insecticide cost at site 3 in 1998 is attributed to the decision in the IPM plot to apply Vendex after harvest in order to control a rapidly increasing twospotted spider mite population, which exceeded the WSU recommended action threshold for this pest. The mite population subsequently increased in the Traditional plot to 120 mites per leaflet, but the grower chose not to treat. His decision was influenced by the poor fruit quality experienced that year due to fruit rot (*Botrytis cinerea*) which drastically reduced farm income and therefore short-term cash flow. IPM may not always be less expensive in the short term. However, it is a field-specific, knowledge-based, risk reduction approach to pest management. Annual reports on this project, available through WSU Vancouver Research and Extension Unit, provide significantly more detail, which is beyond the scope of this report. Sites 1 and 3 were conducted on the same farms while Site 2 was replaced with Site 4 in 1999.

Table 1. Comparison of Pesticide Costs ($) per Acre in Traditional and IPM Pest Control Programs in Red Raspberries, Whatcom and Skagit Counties.

1998	Traditional			IPM		
	Fungicide	Insecticides	Total	Fungicide	Insecticide	Total
Site 1	105.27	39.00	144.27	98.06	52.00 a	150.06
Site 2	189.28 b	64.50	253.78	147.66	64.50	212.16
Site 3	202.23	49.25	251.48	185.04	100.35 c	285.39
Average	165.59	50.91	216.50	143.58	72.28	215.87
1999	**Traditional**			**IPM**		
	Fungicide	Insecticides	Total	Fungicide	Insecticide	Total
Site 1	296.63 d	52.00	348.63	203.05	52.00	255.05
Site 4	171.60	85.50	257.10	215.37 e	88.20	303.57
Site 3	275.59 f	96.59 g	372.18	174.94	81.40	256.34
Average	247.94	78.03	325.97	197.78	73.86	271.65

Notes

(a) Higher insecticide cost in IPM because grower reduced Brigade rate of application by 25%.

(b) Higher fungicide cost in Traditional due to 4 vs. 3 applications of Rovral and 6 vs. 4 applications of Captan. Fruit intended for IQF (highest-grade fruit).

(c) Higher insecticide cost in IPM due to post-harvest application of Vendex for spider mite control.

(d) Higher fungicide cost in Traditional due to spring Ridomil application for *Phytophthora* root rot suppression.

(e) Higher fungicide cost in IPM due to 3 vs 2 applications of Switch.

(f) Higher fungicide cost in Traditional due to 4 vs 2 applications of Switch.

(g) Higher insecticide cost in Traditional due to 3 vs 1 application of *Bacillus thuringiensis*.

ACKNOWLEDGMENTS:

Special thanks to Curt Maberry for his hospitality and professional courtesy in providing facilities and site based assistance for the satellite station. We also recognize the generous cooperation and commitment extended by Raj Bathe, Frank DeVries, Jerry Dobbins, Rolf Haugen, George Hoffman, Dick Nydam, Randy Honcoop, Tena Ondeck and Dave Youngquist for allowing us to work in their fields. This cooperative model would have never developed without the assistance and the support of the red raspberry industry.

Project No.: 13C-3543-6967

Title: Twospotted Spider Mite Resistance in Red Raspberry Research

Year Initiated: 1996
Current Year: 1999
Terminating Year: 1999

Personnel: Lynell K. Tanigoshi, Associate Entomologist, WSU Vancouver REU; **Patrick P. Moore**, Horticulturist, WSU Puyallup REC; **Jeanette R. Bergen**, Agricultural Research Technologist II, WSU Vancouver REU

Reporting Period: 1999 (Terminal report)

Accomplishments: **1996**, root cuttings were received from the USDA Small Fruits Breeding Program, Corvallis, OR. Five plants were propagated from each clone and maintained as two canes/pot. **1997**, four foot tall plants were all infested in their mid-section with 24-30 adult twospotted spider mites, *Tetranychus urticae*. Three leaves/plant were counted with a mite brushing machine and the area of each leaf measured. Mite counts were taken bi-weekly for 4 to 5 counts. Susceptible standard cultivar was Willamette, and resistant cultivars *Rubus parvifolius* Cherry, Dormanred and WSU 968. Four cultivars, 12 breeding selections and 34 *Rubus* spp. were evaluated for twospotted spider mite resistance in an unheated greenhouse. Six of 34 *Rubus* spp. had one-third as many or fewer spider mites compared with Willamette after the fourth count. **1998**, we retested the same plant combinations as the previous year in an unheated greenhouse. Six of 34 species and two out of ten breeding selections had one-third or fewer twospotted spider mite compared with Willamette after the fifth count. **1999,** germplasm plants used for the past two years in this project were field planted at WSU Vancouver REU in a RCB design with all cultivars, breeding selections and *Rubus* spp. replicated four times. Plants were naturally infested with lower populations of twospotted spider mites/cm^2 compared with the previous two years whose evaluations were made from artificially infested plants grown in a greenhouse.

Results: Since 1997, four cultivars, twelve advanced selections from the WSU Red Raspberry Breeding Program and 34 *Rubus* spp. from the USDA Small Fruits Breeding Program have been evaluated for natural resistance to *T. urticae* in replicated greenhouse trials and a replicated field planting in 1999. Eleven of 22 *Rubus* spp. and seven of eight breeding selections supported one-third as many twospotted spider mites/cm^2 compared with Willamette after the fourth count in the field (Table 1).

Table #1. 1997 Greenhouse study

	Total	Mites/ cm^2	% of Willamette		NCGR seed lot#	Total	Mites/ cm^2	% of Willamette
Cultivars		Jul 8 & 22 & Aug 5 & 19		**Rubus species**			Jul 8 & 22 & Aug 5 & 19	
Dorman Red	483	0.2	18.0	tephrodes	1713	571	0.1	21.3
P. Cherry	1709	0.8	63.6	corchorifolius	1628	732	0.3	27.3
WSU 968	1470	0.4	54.7	sacchalinensis	168	761	0.2	28.3
Willamette**	2014	0.8	100.0	innomenatus*	1039	425	0.3	31.7
Breeding selections				innomenatus	1039	860	0.3	32.0
WSU 1175	1178	0.4	43.9					
WSU 1174	1406	0.6	52.4					

* two plants per clone

** three plants per clone

Table #2. 1998 Greenhouse study

	Total	Mites/ cm^2	% of Willamette		NCGR seed lot#	Total	Mites/ cm^2	% of Willamette
Cultivars		Jul 8&22 & Aug 5&19 & Sept 2		**Rubus species**			Jul 8&22 & Aug 5&19 & Sept 2	
P. Cherry	1590	0.9	20.7	parviflorus	1664	1011	0.5	13.2
Dormanred	1718	0.6	22.4	innomenatus	1039	1291	0.5	16.8
Willamette	7680	2.2	100.0	innomenatus	1039	1928	0.7	25.1
Breeding selections				niveas	1650	2119	1.0	27.6
WSU 1176	2172	0.9	28.3	sacchalinensis	168	2413	0.8	31.4
WSU 1174	2573	1.0	33.5	corchorifolius	1627	2445	0.9	31.8

Table #3. 1999 Field study

	Total	Mites/ cm^2	% of Willamette		NCGR seed lot#	Total	Mites/ cm^2	% of Willamette
Cultivars		Jul 28 & Aug 11 & 25 & Sept 8		**Rubus species**			Jul 28 & Aug 11 & 25 & Sept 8	
Dormanred	4	0.01	2.1	ellipticus	Rub.1052.001	5	0.01	2.7
WSU 968*	15	0.03	10.7	coreanus	1211	6	0.01	3.2
P. Cherry	26	0.13	13.9	corchorifolius*	1627	9	0.04	6.4
Willamette	187	0.20	100.0	sacchalinensis	168	16	0.02	8.6
Breeding selections				coreanus	1634	17	0.03	9.1
WSU 1170	9	0.02	4.8	innomenatus	1039	17	0.03	9.1
WSU 1177	11	0.02	5.9	niveas	1650	18	0.03	9.6
WSU 1173	12	0.02	6.4	pungens	Rub.46.002	23	0.06	12.3
WSU 1049	13	0.02	7.0	rosifolius	1667	33	0.08	17.6
WSU 1171*	11	0.02	7.8	flosculosus	Rub.424.001	41	0.11	21.9
WSU 1174	16	0.02	8.6	innomenatus	1039	51	0.08	27.3
WSU 1176	18	0.02	9.6					

* three plants per clone

None of the cultivar quality clones were consistently resistant to twospotted spider mites. The sources of resistance that will need to be used will be related species. Clones of *Rubus corchorifolius*, *R. sacchalinensis*, *R. innomenatus*, and Dormanred had less than one-third of the number of spider mites as Willamette in all 3 years. *R. coreanus*, *R. niveas*, *R. pungens*, WSU 1174, WSU 1176, and Cherry had less than one-third of the number of mites as Willamette in 2 of the 3 years. These species could be valuable sources of spider mite resistance. All of these resistant clones are either species or species derivatives that are related to the domesticated red raspberry. Crosses with all of these resistant species have been made by the WSU breeding program and hybrids are currently being evaluated for vigor and fertility. Most of the hybrids have at least partial sterility and will require several cycles of backcrosses to improve fruit set.

Project No.: 13J-3543-4977

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

Year Initiated: 1998
Current Year: 1998
Terminating Year: 2000

Personnel: Lynell K. Tanigoshi, Associate Entomologist, WSU Vancouver REU, **Jim D. Chamberlain**, Agricultural Research Technologist III, WSU Vancouver REU and **Tom J. Peerbolt**, Peerbolt Incorporated DBA Peerbolt Crop Management.

Accomplishments:

- Orange tortrix (OT), *Argyrotaenia franciscana*, and general leafroller phenology were surveyed weekly in caneberry crops throughout Clark County, WA and Washington, Clackamas, Marion County, OR. Crops consisted of mainly red raspberry but blueberry, marionberry, boysenberry and blackberry were included to total 54 fields surveyed. Our intention was to re-evaluate leafroller diversity, importance of orange tortrix as a harvest contaminant of red raspberry, and test the efficiency of pheromone based monitoring to target potential harvest contaminants. Additionally, the carnation tortrix (CNT), *Cacoecimorpha pronubana*, was posed as a possible harvest contaminant last year due to large trap counts and this needed to be verified. We defined larval features that will help growers separate OT from CNT.

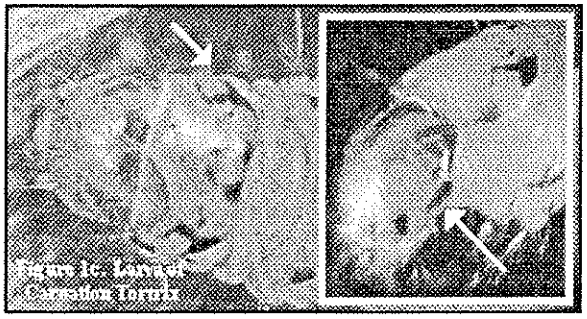
- Pheromone traps were placed in each field and counted weekly. The pheromone for OT was used for this survey. OT lures consist of two components, (Z)-11-tetradecenyl acetate and (Z)-11-tetradecenal. This pheromone blend is known to draw in obliquebanded leafroller, *Choristoneura rosaceana*, carnation tortrix and European leafroller, *Archips rosana*. To relate adult male flight activity with larval phenology, larval collections were made at each field. To standardize relative larval abundance, 30 minutes were spent searching and hand collecting rolled leaves during each weekly visit.

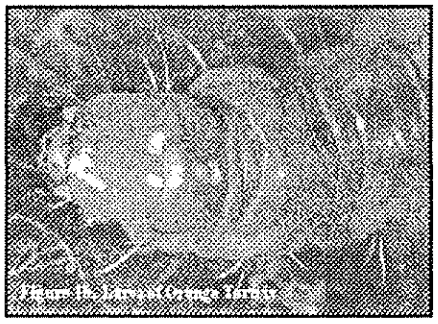
- Field collections were brought back to the lab for processing. Each larva was cataloged and placed individually into rearing containers. A general pinto

bean based diet was used to rear out each collected larva. Once the contents of the rearing cup reached adulthood, the emergence date was recorded and specimens were preserved. These then, were pinned, mounted and labeled for identification.

- Field collected orange tortrix larvae from blackberry tips were bioassayed with several registered and experimental biopesticides. They were applied on infested blackberry tips with a precision Potter Spray Tower. Five infested tips/Petri dish/treatment were replicated three times. The five tips were treated with 2 ml of solution; then, turned over and sprayed with another 2 ml. Tips from each replicate were transferred to one pint plastic containers and covered with fine mesh cloth held down with a rubber band. Mortality evaluations were made 2 and 5 days after treatment. Bare or free-living larvae were topically treated with the same materials used for the nested larvae. Two replicates of 10 larvae each were treated with 2 ml of toxicant delivered through the Potter Tower. They were held in containers as above along with an untreated blackberry tip. .

Results: Although the carnation tortrix is trapped in very high numbers, CNT is currently not an issue to the red raspberry industry as a harvest contaminant and is attracted to the pheromone traps from other host plants. Of all fields surveyed, only a few larvae were collected. However, it should be made aware that it still could pose a threat to contamination in the future. CNT was found to be a dominant species in one field located in Oregon. CNT can easily be confused with OT. With use of a hand-lens, one can distinguish the two species. CNT has dark markings on the prothoracic shield behind the head capsule and on the gena (cheek) of the larva (Figure 1a) while OT is usually free of any markings (Figure 1b).





Pheromone trapping is a very effective tool for tracking populations and timing applications. Due to the late season in 1999, neither species was much of a threat to harvest (Figures 2a & b). Normally, OT larvae would be maturing at the

crucial time of harvest and a clean-up spray would be timely to control OT contamination.

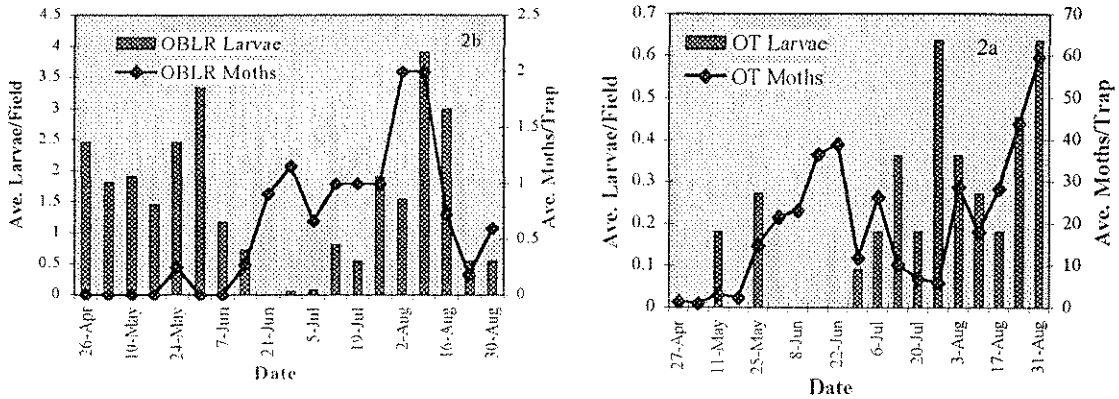


Figure 2. Weekly average trap catch relative to average number of larvae collected per 30 minutes of searching for both orange tortrix (2a) and oblique-banded leafroller (2b).

Brigade (bifenthrin) provided excellent knock-down as a contact and stomach poison within two days after treatment (Table 1). The experimental bioinsecticide Success (spinosad) provided good oral activity compared with its contact mode of action in the lab. Five days after treatment, the other experimental fermentation product, Proclaim (emamectin benzoate), molting hormone disrupter, Confirm (tebufenozide), and novel inhibitor of sodium ion entry into nerve cells, Auvant (indoxacarb), provided nearly comparable results with Brigade when applied as oral toxicants. Despite good coverage, the two Bt protein toxins performed poorly when applied either as a foliar or topical treatment. Because we combined rather than individually isolating the 20 OT larvae into two replicates, results for bare larval exposure were statistically insignifcant. We will continue to refine our laboratory bioassy protocol with mass reared OT larvae obtained from different geographic localities.

We suspect that populations of OT have already developed tolerance to the pre-harvest treatment, Brigade. We have collected observational data from the past two years confirming the development of resistance in one field in Clark County. Larvae treated with Brigade from susceptible populations instantly regurgitate and die within 48 hours while the suspected resistant population showed no symptoms of this effect. New resistant management tactics need to be explored and implemented in areas where OT poses as a harvest contaminant.

Table 1. Larvae from Blackberries on Sauvie Island, OR, 1999.

		% Dead			
		Nests		Bare Larvae	
Material	Larvae Found	48 Hours	120 Hours	48 Hours	120 Hours
Control	7	0.00b	0.00c	5.00b	10.00a
Match (MVP II)	9	0.00b	0.00c	10.00b	25.00a
Success	12	93.33a	93.33a	30.00b	30.00a
Proclaim	8	0.00b	83.33ab	5.00b	75.00a
Confirm	11	8.33b	55.00ab	20.00b	45.00a
Brigade	13	100.00a	100.00a	100.00a	100.00a
Avaunt + Kenetic	9	0.00b	72.33ab	10.00b	30.00a
Javelin	9	0.00b	36.67bc	10.00b	15.00a

Means within the same column not followed by the same letter differ significantly ($P = 0.05$; LSD).

Project No.: 13J-3543-4977

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

Year Initiated: 1998
Current Year: 1999
Terminating Year: 2000

Personnel: Lynell K. Tanigoshi, Associate Entomologist, WSU Vancouver REU, **Todd A. Murray**, Research Associate, WSU Vancouver REU and **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 their larval instars web and feed on foliage and maturing fruit. The traditional control strategy is a chemical program consisting of a prebloom spray in early May and a clean-up spray before harvest. Insecticides registered for these two timing intervals include the organophosphates azinphos methyl (Guthion) and malathion, the carbamate carbaryl (Sevin) and *Bacillus thuringiensis* (Dipel 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 Bt. 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. These insecticides have been shown to be very target specific, effective at low rates, but safe to the environment and human health. Preliminary evaluations in cranberry with biorational insecticides (NJ, WA) indicate good potential for their integration within future biologically intensive pest management programs. These programs will include strategies such as mating disruption and conservation of a complex of parasitoids identified in commercial fields of red raspberry in the Pacific Northwest.

Objectives:

- Field test several biorational insecticides and newer formulations and biotypes of *Bacillus thuringiensis* for orange tortrix control under field conditions.

- Evaluate pheromone traps as decision making indicators for aspects of orange tortrix field distribution, estimate of male emergence, their population density and correlation with major egg hatch in June and spray recommendations (timing).

- Conduct laboratory bioassay protocols to measure insecticide tolerances of several different populations of orange tortrix larvae to both experimental and register insecticdes. for fieldmen and researchers.

Procedures:

- Replicated field trials will be conducted at several known infestation sites in Clark and Cowlitz counties and blackberry sites om Sauvie Island in Multnomah County, OR. Treatments will be full coverage sprays applied with a tractor mounted 6 tank plot sprayer with an over the row boom using 13 D3-25 TeeJet nozzles per row at 200 psi, delivering 89 gal/acre at 3 mph.

- Various densities of pheromone traps will be in place by 1 April. In addition to the provisional treatment threshold of 25 moths/trap/week, we will conduct weekly visual examinations of terminal foliage and beating tray sampling for early larval instar activity. These sampling methods will provide empirical data to assess impacts of standard and biorational treatments on the natural enemy complex.

- Laboratory reared orange tortrix can now be mass-reared on an artificial diet developed at WSU NWBIQ. This rearing system will provide us with timely numbers of even-aged orange tortrix larvae for which replicated treatments with our precision Potter Tower can be conducted throughout the season.

Anticipated Benefits and Information Transfer: Expanding our biological knowledge of 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 applications of insecticides.

Information from this applied research project will be used to support a request to the IR-4 program and the Washington Pesticide Commission for Pesticide Registration. Because biorationals such as IGRs, microbial insecticides and non-neurotoxic mode of action pesticides (e.g., spinosad, emamectin benzoate) are low risk insecticides, 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
07	Employee benefits (16% of 01)	480
Total		**$3,480**

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
Tom Peerbolt, Peerbolt Crop Management
COOPERATOR: **J. Scott Cameron**, Director & Ass't Dean, WSU Vancouver REU

REPORTING PERIOD: 2000

ACCOMPLISHMENTS:

1. 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 inch split trellis (ST) compared to the conventional trellis (CT) in Lynden, WA.
2. 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.
3. Rough cost analysis was completed and indicated significant profit advantage for the split trellis if the approximately 20% yield advantage can be maintained.
4. Environmental data collected in the field in order to study cultural phenology.
5. New set of pruning timing trials initiated.

RESULTS:

Split Trellis Training System: Research with a new, machine harvestable split trellis continues to be very promising. Over the last three years, the split trellis has performed differently than the conventional trellis in a number of ways. Increased light exposure (confirmed again this year) within and to the surface of the split canopy has consistently resulted in increased leaf number, leaf area, and berry number throughout the canopy, but particularly in the upper parts of the canopy where we've documented more light is available early in the season. This increased productivity consistently results in estimated yield potential that is 20-50% greater for the split trellis. Actual yields have varied from 0 to 33% greater for ST, but have been more consistently in the 10-13% range with yields being limited by various factors, depending on location.

In 1999, yield of the split (ST) vs. conventional trellis (CT) was again compared in "Meeker" red raspberry. Field-testing was repeated at four sites in north (Lynden) and southwest (Woodland, Ridgefield, WSUV REU) WA. A variety of widths (17, 18, 20 in), crossarm styles and machine harvesters were tested in fields with varied cultural practices. Topped and tied-over canes were compared at two locations. Three sites were machine picked. This year, Littau Harvester suggested simple adjustments to their machine that, where correctly implemented, resulted in a 19.4% increase in yield for the 20 inch ST at Honcoop's in Lynden. Damage (virtually none detected) 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 RPMs with the turn of a dial. This is very significant because we have now reached a level of yield increase where

increased profits will substantially offset costs attributed to the ST. A rough estimate of costs/benefits at Honcoop's, assuming a hypothetical price for fruit of $.50/lb, translates into a profit for ST of $683/acre for the installation year, and $935/acre for the following years. This was based on actual yields of 7.5 and 6.3 tons/acre for ST vs CT respectively. A similar comparison between a 5 ton yield/acre (CT) vs a 6 ton yield/acre (ST) nets 16% more dollars/acre/yr for ST after the first year installation costs have been applied.

ST yield increases were not as great at the other locations (Ridgefield, 11%) due to some difficulties with harvest, but this led to our breakthrough in yield at Honcoop's where harvest occurred later. Lateral damage was minimal in Lynden, but higher in the other locations where machine adjustments were made too late or not at all. Most damage occurred early in the season, particularly in the most productive upper third of the canopy, and thus had a greater impact on yield. In Woodland estimated yield potential was 22% greater for the 20 inch ST, but actual yield was incomplete due to a shortage of labor. There was no significant difference in harvest efficiency between treatments at WSUV. More fruit was lost to drop in the middle of the row for ST in Lynden. Topped canes in the CT and ST had reduced yields of 11 and 19% respectively compared to their tied-over counterparts. Topped ST canes had 11% greater yield than topped CT canes. There were no significant differences in leaf physiology/biochemistry between treatments with regard to CO_2 assimilation, chlorophyll or total nitrogen content. Increased ST yields were recorded for a second year at two locations, which supports sustainability for yields with this trellis design.

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. The study considered cane removal dates after harvest as well as dates in Sept, Nov and Feb. This preliminary study has given us the information we need to suggest that later removal is beneficial. 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. In 1999, we have reestablished this trial. Canes were removed after harvest in one treatment and will be removed every two months for a total of four pruning dates. Effects of treatments on yield will be evaluated next season.

Phenology and Temperature. 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 1999, we monitored relative humidity, soil and air temperatures within raspberry canopies under study throughout the season. We are attempting to take the limited data we have at this time and compare it with general growth patterns, life cycles, etc.

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.

PROJECT NO.: **13C-3555-5784**

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

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
J. Scott Cameron, Director & Ass't Dean, WSU Vancouver REU
Lynell K. Tanigoshi, Associate Entomologist, WSU Vancouver REU
Peter R. Bristow, Associate Plant Pathologist, WSU Puyallup 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 while developing cost effective strategies to increase the efficiency of production.

OBJECTIVES: **(All to be addressed in 2000)**

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.

PROCEDURES:

Split Trellis Training System: Prior to the development of mechanical harvesters, growers were using two wire, T-trellises with canes trained to each. When beater bar harvesters were used, industry moved to a narrower canopy trained to a single top wire. This closed our canopy and excluded light, which has meant significant yield losses due to shading. With the advent of rotary harvesters, it is possible to have a wider fixed opening for harvest, which can accommodate a wider trellis. This system incorporates many of the factors we have identified as being biologically important to increasing efficient, sustainable production which recovers lost yield potential.

Owing to the continuing success of research plot and grower-based trials and widespread industry interest, we continued to focus on the split trellis as our primary research project in 1999. The project encompasses multiple trials in north and southwest WA and massive amounts of data were collected. In 1999, we made a major step towards adapting this trellis for industry use by overcoming the two primary problems limiting greater yield increases (lateral damage) and quality (premature pick of green fruit) in the split trellis thus far. Littau Harvester demonstrated how to simply adjust their machine so that these problems were minimized. The result was a 19.4% increase in yield for the split trellis at Honcoop's with very little green fruit. A rough cost analysis showed that yield increases of this magnitude result in substantial profit when weighed against added costs of the split trellis using Honcoop's trellis design. As we continue to move forward with this research, we now need to repeat these results for 3 or preferably more consecutive years in at least one location to make sure yields remain sustainable. Our research has shown this is the case for two consecutive years, but then growers were unable to continue the trials in their fields. This work and other fine-tuning of this system can be most easily done at the WSU Vancouver Research Unit, but borrowing a harvester each year has been problematic and we have no permanent solution to acquiring one. Perhaps the WA Red Raspberry Commission has some suggestions in this regard. Other questions needing further study include long term effects of this system with regard to insect, mite and fungal pests as well as nutrition. Thus far, no major differences have been seen between trellis systems, but this year a small but significant increase was seen in the split trellis for European red mite in August in Lynden. We have made significant progress in identifying and evaluating the issues that will need to be addressed as we move forward with advanced testing of this new system. We propose to continue our studies with this system while studying the components of productivity in conventional and alternative systems. This effectively expands the model of study we were using with an opportunity to set more realistic parameters and to recover more data related to important issues such as labor costs and economic returns.

Our cooperator in Lynden has removed his trial, so we propose establishing one new site in that area that will be funded by grant money from the "satellite" proposal. In the southern part of the industry, we propose to use some funds from this grant to assess plots established in Woodland, Ridgefield and our new planting at the Vancouver research station for a third consecutive year. We will focus our studies more on actual machine-picked yield, pest dynamics and cost/benefit analyses. Trial widths of 17 and 20 inches will be assessed in at least one location to see if there are significant differences in yield. Our data, thus far, show that decreases in width will result in less yield increase with the split trellis, but growers are interested in using as small a width as possible. While we will assess performance at a range of locations, we propose to concentrate replicated studies with more intensive data collection at one site in Lynden, one in Woodland, and at the Vancouver research station.

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.

Date of Floricane Removal. We have re-established this study in our planting in Vancouver. This year, because harvest lasted into mid-August, floricanes will again be removed in August, October, December 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.

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.

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 1999**	**Requested 2000**
Temporary employees	$7,500	$7,500
Supplies and services	1,000	1,000
Equipment	------	600
Travel	800	800
Benefits (16% of 01)	1,200	1,200
TOTAL	**$10,500**	**$11,100**
	$7,000 FUNDED	

Note: With more on-farm research sites, we will require more labor for specific site based work. Due to his excellent assistance and cooperation with on-farm trials in the last 3 years, we have asked Mr. Tom Peerbolt to continue to work with us as a cooperator to oversee some of the harvest and data collection in on-farm plots.

OTHER SUPPORT OF PROJECT:

Part of the funds for the WSU V R and E Unit "satellite station" have been requested to fund the northern trellis site.

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

Project No.: 13C-3761-7784

Title: Evaluating new fungicides for control of Phytophthora root rot and testing the pathogen for resistance to Ridomil and related compounds

Personnel: P. R. Bristow, Associate Plant Pathologist
G. E. Windom, Agricultural Research Technologist III
Washington State University, Puyallup Research and Extension Center

Reporting Period: 1999 (Terminal report)

Accomplishments: Two new fungicides (Anchor and Acrobat) reduced damage from root rot caused by *Phytophthora fragariae* var. *rubi* under field conditions. Anchor was considerably more active than Acrobat. Yield from plots treated with Anchor far-exceeded that from the untreated check plots or those treated with either Aliette or Ridomil. Few, if any, fruiting canes were present in plots treated with Curzate, Banol or Fluazinam so they were not harvested in 1999.

Results: The mild and rainy weather during winter followed by a prolonged period of rain and cold weather during spring 1999, favored disease development. Few overwintering canes survived unless they were treated with either Anchor or Acrobat (all fungicides were applied to the soil at planting (May 1996) and then every fall and spring thereafter). The canes that died looked healthy in the fall when they were tied to the trellis. Plots treated with either Ridomil or Aliette looked the same as the untreated check plots. Laterals on plants treated with either Anchor or Acrobat emerged earlier and were more vigorous than those on plants in the other treatments. In contrast, many laterals on plants in the Ridomil-treated and untreated check plots collapsed soon after growth resumed in the spring. While a few primocanes wilted in plots treated with Anchor and Acrobat the highest number of healthy primocanes were produced in plots treated with those two fungicides. Oxadixyl, the active ingredient in Anchor, is also the active ingredient in Recoil the fungicide used in Europe to control this root disease.

It is highly unlikely that Anchor will be developed for release in North America. One reason is that the active ingredients in Ridomil and Anchor both belong to the same class of compounds. If the root rot fungus develops resistance to one, the chances are that it will be resistance to the active ingredient in the other product and vice versa. It is surprising that Anchor continued to provide protection in a location where Ridomil was not longer effective. Data from tests looking for resistance to Ridomil suggests that the fungus at this site is still sensitive to the fun-

gicide and that the lack of performance might be due to some other, as yet, unknown cause. The level of control from Acrobat is very low and its registration should not be persued.

Appendix

Table 1. Yield and data on fruiting canes and primocanes, 1999[z].

Treatment	Primocanes produced in 1998 (to become fruiting canes in 1999)		No. fruiting canes tied to trellis per plot	Yield, Kg per plot[y]	No. healthy primocanes per plot in fall 1999
	No. per plot	Height, cm			
Untreated	1.0	6	0	.000	0.3
Ridomil	18.5	68	13.8	.034	6.5
Acrobat	74.5	112	21.3	1.124	38.3
Anchor	188.5	133	85.8	8.633	121.8

[z] Planting established in May 1996, with 10 Willamette plants per plot. Experimental design: randomized complete block with four blocks.

[y] Plots harvested by hand on nine dates between July 5 and August 3, 1999.

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 Cooperative Extension, Chehalis

Reporting period: 1999

Accomplishments: 1999 was the first 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 and 3) a high rate of gypsum in an integrated approach to 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 keeping plants healthy. To date, the results for gypsum are extremely encouraging because plants are still benefiting from gypsum applied two years ago. It remains to be seen how long the effect will last. It also raises questions. Can the 6 ton per acre rate for gypsum be reduced and still maintain a useful level of disease control? Can gypsum be re-applied to established plants to restore a useful level of disease control?

Results:
Raised beds. Since planting, the raised beds have settled and eroded reducing their original height of 12-13 inches by 3-4 inches. To rebuild the beds, tilled soil from the alleyways on either side of the beds was thrown up around the base of the plants in fall 1998. Roots originating from the below ground portion of new primocanes grew into this added soil during 1999. Maintaining the height of beds is critical to keeping soil moisture at a level that is unfavorable for activity of the fungus.

Soil moisture. The planting was irrigated with an overhead sprinkler system. Soil moisture data from tensiometers placed at several depths in both flat and raised beds showed that soil in the raised bed remained drier than soil in flat beds at the same depth beneath the surface. The surprise was that soil beneath the original soil line in raised beds was also drier when compared to soil at the same depth in flat beds. At least two factors may have contributed to this phenomenon. Some of the water from rain and irrigation may run off the raised bed rather than

percolate through soil in the bed. The root system of plants on raised beds may be considerably larger than that of plants on flat beds. 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 also healthier.

Ridomil. The contribution of Ridomil to controlling the disease may be less than it was several years ago. Since the early 1990's, plants treated with the fungicide at this site have not been as vigorous as plants in earlier experiments where near 100% control was achieved. Even with reduced efficacy, Ridomil use represents a positive contribution to the integrated plan.

Appendix

Table 1. 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	0.36 d[y]	2.05 cd	1.06 d	3.75 b
	Raised	2.19 cd	0.14 d	4.43 b	7.60 a
Skeena	Flat	0.64 c	0.84 c	3.46 b	3.65 b
	Raised	3.26 b	6.02 a	3.02 b	6.89 a

[z] Eight plants per plot at planting.
[y] Data from each cultivar were analyzed separately. Duncan's Multiple Range Test (P=5%).

Table 2. Effect of cultivar, bed type, fungicide treatment and gypsum amendment on fruiting canes in 1999.

Comparison	Fruiting canes per plot, no.		Yield, kg per plot		Yield per fruiting cane, grams per cane	
Meeker vs. Skeena	38.9 66.8	*[z]	2.62 3.47	n.s.	60.9 49.4	*
Flat bed vs. Raised bed	32.6 67.6	***	1.61 4.31	***	49.5 64.3	*
No Ridomil vs. Ridomil[y]	40.0 61.6	*	2.23 3.80	*	55.8 56.0	n.s.
No Gypsum vs. Gypsum[x]	34.6 65.6	***	1.79 4.13	***	50.3 60.9	n.s.

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

Table 3. Impact of bed type, Ridomil and gypsum on the number of healthy primocanes by cultivar.

		Healthy primocanes per plot, no.[z]			
Cultivar	Bed type	None	Ridomil	Gypsum	Ridomil + Gypsum
Meeker	Flat	6 e[y]	14 e	29 de	70 bc
	Raised	50 cd	58 cd	94 ab	116 a
Skeena	Flat	84 c	100 bc	216 a	180 abc
	Raised	156 abc	172 abc	166 abc	200 ab

[z] Eight plants per plot at planting.
[y] Data from each cultivar were analyzed separately. Duncan's Multiple Range Test (P=5%).

Table 4. Effect of cultivar, bed type, fungicide treatment and gypsum amendment on primocanes in 1999.

Comparison	Primocanes per plot, no.		Wilted primocanes, %		Length of healthy primocanes, cm	
Meeker vs.	57.9	***[z]	10.1	*	143	***
Skeena	172.3		3.2		194	
Flat bed vs.	80.1	*	10.9	*	152	n.s.
Raised bed	127.3		3.8		175	
No Ridomil vs.	90.7	n.s.	8.7	n.s.	157	n.s.
Ridomil[y]	118.5		5.5		171	
No Gypsum vs.	77.2	**	7.8	n.s.	148	*
Gypsum[x]	130.1		6.6		179	

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

Project No.: 13C-3761-6718

Title: Integrated control of Phytophthora root rot.

Year initiated: 1994 **Current year:** 2000 **Terminating year:** ongoing

Personnel: Peter Bristow, Associate Plant Pathologist and Gwen Windom, Agricultural Research Technologist III
Washington State University, Puyallup Research and Extension Center

Justification: Root rot, caused by the soil-borne fungus *Phytophthora fragariae* var. *rubi*, is the most serious root disease of red raspberry in the Pacific Northwest. In attempting to develop control measures for this disease, it has become clear that any single approach or method will not provide the level of control required for this high value crop. Since 1982, growers have been able to use the fungicide Ridomil (metalaxyl) and more recently its replacement product Ridomil Gold (only the active isomer of metalaxyl) to successfully control the disease at many locations. Increasingly, there are locations where it apparently is no longer effective. In test plots at the WSU-Vancouver Research and Extension Unit, we experienced our first failure in nearly 20 years of working with the fungicide. Aliette (fosetyl-Al) also has activity against *P. fragariae* var. *rubi*, but in the past, it was not as effective as Ridomil. In fields, where Ridomil is no longer effective, Aliette may be the material of choice. Newer compounds were tested but only Anchor has the high level of activity needed. Because the active ingredient in Anchor is in the same class of compounds as the active ingredient in Ridomil Gold, it is unlikely that Anchor will be developed for this use.

Efforts continue in the breeding program to select for resistant genotypes. To date, even the most resistant source yielded more when treated with Ridomil. One selection in the breeding program has performed will on infested ground at the Farm 5 site near Puyallup and it has desirable horticultural traits.

Growing red raspberries on ridges dramatically lowered the incidence and severity of root rot. This was demonstrated at a site where the soil drains poorly and is naturally infested with the pathogen, hence, disease pressure as very high. Combining chemical control (metalaxyl) with the raised beds improved plant growth even more. Researchers in the eastern U.S. showed that incorporating gypsum at a high rate into soil prior to planting suppressed this disease. Now, two years after planting into gypsum amended soil disease suppression is still being observed. In order for an integrated strategy to be considered successful on a perennial crop

red raspberry, it must be able to sustain production over many years. For that reason, treatments must be continued and field plots evaluated for several years. The goal is to develop an integrated program that controls the disease and gives growers the greatest number of options.

Objectives:

1. To continue to evaluate the following approaches to disease control alone and in combination:
   a. Raised vs. flat beds.
   b. Susceptible variety (Skeena) vs. a tolerant variety (Meeker).
   c. Gypsum added to the soil before planting vs. no gypsum.
   d. Ridomil applied twice yearly vs. no fungicides.

2. Determine how long gypsum applied just prior to planting will suppress root rot

3. Determine if surfactants added to the soil will help to suppress root rot.

Procedures: A field trial was established on a site with a history of Phytophthora root rot. The eight treatments (each replicated three to four times) will be evaluated on an ongoing basis. Gypsum at a high rate (6 tons per acre) was applied and worked into the soil of designated plots before bed shaping and planting. Soil will continue to be tested pH. Raised beds will be restored to near their original height by throwing soil from the alleyway up around the base of plants in the fall. No additional gypsum will be applied. Tensiometers will be placed in both raised and flat beds to monitor soil moisture. Ridomil will be sprayed on the soil surface each spring and fall. During 2000, symptoms will be recorded, disease incidence and severity evaluated, and cane growth measured. The plots will also be harvested for yield.

In selected plots, a surfactant will be applied to the soil in early spring and in the fall once the rains begin. Surfactants have been shown to destroy zoospores of *Phytophthora* and *Pythium* in several crops grown in hydroponic culture.

Anticipated Benefits and Information Transfer: All three factors; Ridomil, raised beds and gypsum continue to contribute to disease control. The results are very encouraging considering Skeena is extremely susceptible to this disease. Identifying non-chemical control measures should help to maintain the useful life of effective fungicides that are registered for this use. Moreover, development of an effective integrated control program will allow sites that become infested with the root rot fungus to continue to be used for red raspberry production.

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:

Commission funding for FY1999-2000	$3985
Request for FY2000-01	
Timeslot labor	2,600
Operations	800
Travel	
Projected needs	300
Meetings	104
Employee benefits	416
Total	$4,220

Other Support of Project: Ridomil Gold donated by Novartis.

Progress Report to: Washington Red Raspberry Commission

Title: Engineering resistance to raspberry bushy dwarf virus

Robert R. Martin, USDA-ARS, 3420 NW Orchard Ave., Corvallis, OR 97330;
Helena Mathews, Agritope, 16160 S.W.Upper Boones Ferry Rd., Building C, Portland, OR 97224.

Reporting Period: 1999

Accomplishments: Sequence of raspberry bushy dwarf virus coat protein and movement proteins has been completed. The movement protein has been mutagenized to give four different mutants as well as a nontranslatable RNA. These constructs have been cloned into a plant expression vector (Agritope's) and inserted into *Agrobacterium tumefaciens* (crown gall pathogen, with the genes for gall production removed and our favorite gene [RBDV genes] inserted). Transformation of the six constructs into 'Meeker' raspberry has been carried out and most of the transformants are now in the field in Northern Washington and in Oregon, as well as being maintained in tissue culture and in a screenhouse. Grafting the transformants with RBDV infected material has been started. To date most of the 53 transformants that have been tested have not become infected with RBDV. The grafting will be completed this winter and then all clones testing negative for RBDV will be regrafted with RDBV infected source material.

A minimum of 50 different transformation events have been prepared for each construct, this will allow selection of clones in which the inserted gene has not disrupted an essential plant function. For example, if the fruit releases from the plant with more difficulty or easier than regular 'Meeker' that transgenic line would be eliminated from trials. We need to select from the total of over 300 transgenic lines that have been produced for virus resistance and still appear to be the same as regular 'Meeker' in every respect. The same strategy will be used of the tobacco mosaic virus transgenic raspberries that are now being developed. Two plants of each construct are being maintained in a greenhouse for graft inoculation with RBDV. PCR tests have been done on a subset of plants to ensure that the genes are present. Plants for field trials were hardened off in a screenhouse prior to field planting.

Field trial applications have been approved by APHIS for both Oregon and Washington. The established field trials show much variation in the growth rate of the plants but this appears to be due to the condition of the plants when they were moved to the field as there are often inconsistencies between plots of the same clone. Evaluations on fruit quality, plant growth etc. will be more intensive over the next few years. Off-type plants will be removed from the trials. Also, field plants will be tested for RBDV each year to determine rates of reinfection of each clone and to identify resistant lines.

Washington Red Raspberry Commission

Title: Engineering resistance to raspberry bushy dwarf virus

Year Initiated 1996 Current Year 2000 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 nontranslatabe 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).
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.
8. Develop new transgenics with mutated movement protein of tobacco mosaic virus, this construct gave resistance to tobacco streak which has similarities to RBDV. 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 1999		13,000
Request for 2000		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.

Current & Pending Support

Name	Supporting Agency	Total $	Dates	% of Time	Project Title
Current					
Martin & Mathews	WA Red Rasp Comm	13,000	1999	8	Resistance to RBDV
Martin & Mathews	BC Rasp Council	13,000 (CA)	1999	8	Resistance to RBDV
Martin & Mathews	OR Rasp &Blackberry	4,000	1999	5	Resistance to RBDV
Martin	OR Wine Adv Board	7,500	1999	5	Grape virus survey
Martin & Mathews	SBIR	15,000	1999	8	Resistance to RBDV
Martin	USDA	80,000	99-2001	5	Transmission of RBDV
Martin	NWCSFR	12,000	1999	5	Virus Clean Up Program
Pinkerton & Martin	NWCSFR	7,500	1999	5	Management of TomRSV
Pending					
Pinkerton & Martin	NABGA	2,000	2000	5	Management of TomRSV
Pinkerton & Martin	OR Rasp&Blackberry	4,750	2000	5	Management of TomRSV
Pinkerton & Martin	WA Red Rasp Comm	4,750	2000	5	Management of TomRSV
Martin & Mathews	BC Rasp Council	13,000(CA)	2000	8	Resistance to RBDV
Martin & Mathews	OR Rasp & Blackbery	4,000	2000	5	Resistance to RBDV
Martin	NWCSFR	6,000	2000	5	Virus Clean Up Program
Pinkerton & Martin	NWCSFR	10,450	2000	5	Management of TomRSV

Progress Report

Title: **Red Raspberry Cultivar Development for the Pacific Northwest**

Personnel: Chaim Kempler and Hugh Daubeny
Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre
PO Box 1000, Agassiz, BC, Canada V0M 1A0
Tel.: 604-796-2221 ext: 224, Fax: 604-796-0359, Internet: KemplerC@em.agr.ca

Reporting Period: 1999

Funding: In 1999 funds were received from the B.C. Raspberry Growers Research Council, Washington Red Raspberry Commission, Lower Mainland Horticultural Improvement Association, royalties collected on PARC cultivars and Agriculture and Agri-Food Canada Matching Investment Initiative.

Objectives: Develop red raspberry selections stressing 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 1999, about 350 seedlings were planted in the field. They were all from previous crosses with at least one parent that is resistant to RBDV. Thirty-seven new selections were made among the 1993 crosses; seven will be used only for breeding and the other thirty will be propagated and planted for further evaluation. We have established new plantings with forty-four clones (Planting 99). We evaluated the 1993, 1994, 1996 and 1997 replicated plantings during the 1999 harvest season. Data on yield, fruit size, harvest season, post-harvest fruit rot, fruit firmness and Brix is presented in tables 1, 2 and 3.

Notes on cultivars and potential new cultivars:

Qualicum - Recommended for trials. Fruit is large, firm and well adapted for fresh market and long distance shipping. Trials show that it is suitable for mechanical harvesting. Under vigorous growing conditions this becomes difficult; however, excess growth can be controlled by lowering nitrogen levels. It shows excellent winter hardiness.

Malahat - 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 growers' trials Malahat was suitable for machine harvesting producing high quality IQF and processing crops. Because Malahat ripens earlier than Meeker, it has allowed the producer a longer harvest season and better utilisation of the harvesting equipment. Malahat is susceptible to root rot; therefore 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.

Kitsilano - A newly named selection that is a very late-ripening raspberry suited to the fresh market. The fruit is medium size; glossy medium red; relatively small drupelet; very firm; easy to harvest; good flavour; some resistance to both pre- and postharvest *Botrytis*-incited rots; extended season, ripening later than Tulameen with an overlap in some years with early primocane fruiting varieties. The plant produces high yields; moderate numbers of canes; spines general but not objectionable; winter hardiness similar to Meeker and less than Chilliwack. Relatively susceptible to spur blight (*Didymella applanata*) and cane *Botrytis*; susceptible to root rot; susceptible to RBDV but the rate of infection appears to be slow; resistant to the aphid vector of the raspberry mosaic virus complex.

BC87-14-20 - Selected from a cross between Newburgh and Qualicum. The Newburgh variety was introduced in 1929 from a cross made between Newman x Herbert. It is not a very productive variety, has small fruit, but it is resistant to RBDV, root rot and it is relatively winter hardy. Combining it with the high productivity of Qualicum, with its large fruit size and good fruit quality, made it a very successful cross. Although it has not been confirmed and more testing is needed, BC87-14-20 plants show good resistance to root rot and have so far tested negative to RBDV. In the research plots it was vigorous, moderately productive, and produced attractive large fruit that was firm, glossy and had excellent flavour and aroma (Tables 1b, 2, 3). In a grower trial it showed that it is very suitable for mechanical harvesting producing a high yield of medium to large fruit that ripens about one week earlier then Meeker. Plant growth has a vigorous upright habit and a good number of primocanes. Floricanes produce long and strong laterals. Fruit is spaced well apart along the laterals. It appears to be susceptible to cane botrytis.

BC89-2-89 - A late fresh market selection from a cross between Comox and the Scottish variety Glen Ample. It produced high yields of large fruit (5.3 g). This selection will fruit later than any other recommended variety. Fruit is larger than Tulameen, light in colour, with large drupelets. The plant is very vigorous, with strong canes and long upright laterals.

BC89-33-84 - Selected from a cross between Tulameen and PARC selection. A mid season processing and fresh market type that produces attractive dark berries with some resistance to fruit rot. Fruit is easy to harvest and most likely will machine harvest well.

BC89-34-41 - Selected from a cross between two of PARC selections. An early fresh market or processing selection producing high crops with fruit size larger than Meeker. In a grower trial it showed that the fruit does not release well from the receptacle and is not suitable for mechanical harvesting.

BC90-4-48 - A *Rubus strigosus* derivative that produced high yields in the test plots for the last three years. Under high infection pressure this selection became infected with RBDV after four years in the field. It is possible that this selection is susceptible to RBDV infection. We recommend this selection for trials in areas with low RBDV infection pressures.

BC90-6-2 - Selected from a cross between root rot resistance *R. Strigosus* derivative and a selection of Comox crossed with Algonquin. We had noted it for its compact plant habit, extremely late production season and its large meaty fruit. Harvesting it is easy. It produces vigorous new growth, and likely will machine harvest well.

New selections for growers trials:

BC90-5-30 - Very productive.

BC90-81 - 3rd backcross from *R. strigosus* firm; fruit is well spaced on laterals; upright habit; produces large firm fruit.

BC90-8-20 - Mid season light fruit that might be most suitable for the fresh market.

BC92-4-18 - Large fruited early selection that appears to be most suitable for the fresh market.

BC92-5-1 - Productive; produces a mid size dark glassy berry that is most suitable for processing. Low susceptibly to fruit rot.

BC92-9-39 - Produces very large fruits that harvest very well. Some fruits are as large as 12 g. Fruit is dark and is suitable for processing.

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.

For more information on new varieties and selection visit my Internet site at: **http://res.agr.ca/agassiz/biograph/kempler.htm** or contact me at the Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre in Agassiz (Tel.: 604-796-2221 ext: 224) or during the growing season visit the experimental plantings at the Agassiz Sub-Station, 510 Clearbrook Rd., Abbotsford. (Tel.: 604-853-1551).

Table 1a. Yield and fruit weight of raspberry cultivars harvested in 1999. Abbotsford, B.C.

Clone	No. of plots	Yield (kg/hill)	Early yield (%)	Late yield (%)	Yield (t/ha)	Fruit Rot (%)	Fruit Weight (g)
93 planting							
86-7-1	1	1.84	8.4	32.7	6.60	3.7	2.3
89-2-46	2	1.07	9.5	19.3	3.84	4.0	3.2
89-2-89	2	1.48	12.9	36.5	5.31	5.5	3.6
89-6-12	3	1.64	41.0	5.8	5.88	1.1	3.1
89-6-13	3	2.42	30.2	14.9	8.68	7.0	3.3
89-33-84	3	1.45	28.8	19.7	5.20	3.3	3.0
89-34-41	3	1.12	17.4	20.3	4.02	1.6	2.8
Meeker	2	1.07	7.2	14.0	3.84	2.2	2.4
95 planting							
86-6-15	4	1.41	39.3	7.8	5.06	1.4	3.0
90-12-50	1	2.27	24.2	23.8	8.14	1.8	3.1
90-5-30	2	1.83	62.8	4.7	6.57	2.6	3.6
90-6-2	3	2.37	22.9	31.7	8.50	5.4	4.5
90-8-11	1	1.77	19.5	20.6	6.35	3.0	3.7
90-8-20	3	1.84	28.3	7.6	6.60	4.2	4.2
Chilcotin	1	1.24	10.1	0.0	4.45	3.5	3.2
Chilliwack	1	0.92	37.4	4.1	3.30	0.9	2.6
Kitsilano	3	1.65	12.2	30.0	5.92	1.7	2.5
Meeker	3	2.10	15.3	26.5	7.53	3.1	2.5
Qualicum	1	2.12	34.0	12.1	7.61	2.2	3.9
Tulameen	3	1.50	15.4	23.8	5.38	4.5	3.8
97 planting							
86-6-15	3	4.90	56.9	1.4	17.58	0.3	4.2
87-18-7	3	7.76	6.8	26.5	27.84	1.7	3.8
89-2-89	2	11.46	7.2	31.7	41.12	2.9	5.3
89-33-84	3	4.49	29.6	8.2	16.11	1.1	3.4
89-34-41	3	8.62	26.1	14.8	30.93	1.3	3.6
89-6-12	2	6.34	45.2	4.4	22.75	1.4	4.6
89-6-13	1	4.68	15.9	25.1	16.79	2.7	3.9
90-4-48	3	6.85	31.3	10.0	24.58	1.0	3.4
90-8-20	1	7.96	38.0	4.1	28.56	1.1	4.9
91-15-40	3	7.64	22.6	20.6	27.41	1.8	4.7
92-10-27	1	4.43	17.8	10.3	15.89	1.3	3.1
92-10-53	3	5.73	37.1	9.4	20.56	2.0	3.7
92-4-18	1	8.56	31.6	16.6	30.71	1.2	4.9
92-5-1	3	6.73	18.4	16.1	24.15	1.1	3.7
92-5-52	2	7.15	22.3	18.4	25.65	1.7	3.5
92-9-12	1	3.61	5.6	26.5	12.95	2.4	5.5
92-9-39	3	4.71	38.3	12.1	16.90	1.5	4.6
OSU 1025-10	1	5.02	3.3	41.1	18.01	1.3	4.7
OSU 1072-11	1	5.27	30.6	9.7	18.91	1.9	3.6
OSU 870R-12	1	4.99	52.3	4.2	17.90	0.7	4.0
WSU 1024	3	7.05	11.0	21.9	25.30	2.3	4.0
WSU 1066	1	5.00	46.9	8.7	17.94	0.8	3.7
WSU 1067	1	5.68	19.6	9.6	20.38	1.0	3.6
WSU 1068	3	7.71	57.4	1.2	27.66	1.0	4.3
WSU 1082	1	5.60	28.8	4.4	20.09	1.1	4.8
WSU 1090	1	6.66	6.7	22.5	23.90	2.3	3.9
WSU 1096	3	5.34	49.4	3.1	19.16	1.4	3.2
WSU 1097	3	6.97	37.4	11.7	25.01	1.1	3.6
WSU 1098	3	5.91	45.8	6.1	21.20	0.4	3.5
WSU 1099	1	9.01	20.3	25.5	32.33	1.1	4.4
Caroline	1	3.20	49.6	20.6	11.48	3.1	3.2
Chilliwack	3	6.13	35.8	3.0	21.99	1.2	3.6
Coho	1	5.20	40.5	4.3	18.66	3.9	3.8
Malahat	3	5.26	54.8	6.7	18.87	1.0	4.5
Maryland	1	7.97	79.2	3.9	28.60	2.0	4.5
Meeker	3	5.59	10.4	21.9	20.06	1.3	3.2
Qualicum	3	7.99	28.2	7.9	28.67	0.8	4.8
Tulameen	3	7.77	20.5	17.9	27.88	2.1	4.9
LSD 5%		2.28	15.0	13.1	8.18	2.3	0.8

Mean separation within columns by SNK multiple range test at 5% level.
Early yield harvested between June 30 to July 19.
Late yield harvested after August 9.

Table 1b. Yield and fruit weight of raspberry cultivars harvested in 1999.

Clone	No. of plots	Total Yield	Early yield (%)	Late yield (%)	Yield (t/ha)	Fruit Rot (%)	Fruit Weight (g)
96 planting							
86-6-15	3	3.03	34.3	6.1	10.87	0.7	4.1
86-7-21	1	6.41	6.8	39.7	23.00	2.4	3.0
87-12-11	1	4.72	17.1	26.1	16.94	2.9	3.2
87-12-32	1	3.24	24.2	14.4	11.63	1.4	3.9
87-14-16	1	6.31	6.1	47.2	22.64	2.9	3.7
87-14-20	3	3.92	20.0	24.8	14.06	1.2	4.8
87-14-35	1	5.34	1.4	57.9	19.16	4.9	3.6
87-18-7	3	4.93	4.3	37.2	17.69	3.6	3.8
87-2-49	2	3.28	47.3	8.6	11.77	0.9	4.8
87-3-37	1	6.37	20.9	25.6	22.86	2.1	4.0
87-5-1	3	4.04	4.9	23.7	14.50	2.4	4.6
87-9-6	1	5.87	30.1	24.4	21.06	1.5	3.7
89-33-84	3	4.46	23.6	19.1	16.00	1.2	4.1
89-34-41	3	5.42	17.0	28.0	19.45	1.7	3.7
90-1-42	1	5.14	34.7	9.5	18.44	0.7	3.1
90-11-44	1	6.40	13.2	41.7	22.96	2.5	3.1
90-2-57	1	3.12	25.3	28.2	11.19	1.6	3.5
90-4-23	1	4.89	47.8	12.8	17.55	0.9	4.7
90-5-30	1	4.16	44.4	9.3	14.93	1.7	5.1
90-8-11	1	5.13	12.1	33.0	18.41	2.9	5.3
NZ8724wd10	1	4.32	40.5	8.8	15.50	1.8	4.6
NZ8724wf 9	1	3.74	20.0	29.3	13.42	1.7	3.3
Beskid	1	6.94	4.2	64.5	24.90	3.5	3.0
Chilcotin	1	5.46	18.3	40.3	19.59	5.4	4.0
Chilliwack	3	3.48	30.3	10.9	12.49	1.2	3.9
Comox	1	5.88	27.6	15.5	21.10	2.6	4.9
Elida	1	4.48	44.8	6.7	16.07	3.4	4.2
Encore	1	2.97	46.0	4.7	10.66	1.3	4.4
Glen Ample	1	7.66	6.4	48.3	27.48	3.9	5.1
Glen Clova	1	6.57	40.5	22.9	23.57	2.3	3.7
Glen Magna	1	5.63	1.8	60.4	20.20	6.2	5.0
Glen Moy	1	6.18	42.4	17.5	22.17	1.7	4.9
Glen Prosen	1	4.86	9.1	48.4	17.44	3.4	3.7
Glen Rosa	1	4.45	7.2	27.7	15.97	2.4	2.5
Glen Shee	1	6.48	14.6	35.1	23.25	5.5	4.6
Haida	1	6.13	23.7	22.8	21.99	1.9	3.0
Kitsilano	3	5.88	6.5	50.3	21.10	2.5	3.3
Malahat	3	5.08	37.5	23.8	18.23	1.2	4.6
Meeker	3	4.14	8.6	31.0	14.85	1.6	3.4
Nootka	1	2.54	33.4	25.0	9.11	2.7	3.0
Prelude	1	6.48	47.1	9.0	23.25	6.4	3.9
Qualicum	3	4.41	28.5	14.2	15.82	1.5	4.9
Skeena	1	3.79	32.2	19.0	13.60	1.2	3.8
Tulameen	3	4.16	18.5	29.7	14.93	2.4	4.6
Willamette	1	2.67	29.9	13.5	9.58	1.3	3.8
LSD 5%		**2.28**	**15.0**	**13.1**	**8.18**	**2.3**	**0.8**

Mean separation within columns by SNK multiple range test at 5% level.
Early yield harvested between June 30 to July 19.
Late yield harvested after August 9.

Table 2. Season of raspberry cultivars harvested in 1999, Abbotsford, B.C.

Clone	First harvest (date)	50% harvest (date)	Harvest Duration (days)
93 planting			
86-7-1	21-Jul	26-Jul	28
89-2-46	21-Jul	30-Jul	21
89-2-89	21-Jul	30-Jul	28
89-6-12	12-Jul	21-Jul	25
89-6-13	18-Jul	26-Jul	28
89-33-84	11-Jul	26-Jul	38
89-34-41	18-Jul	26-Jul	28
Meeker	9-Jul	26-Jul	32
95 planting			
86-6-15	12-Jul	19-Jul	26
90-5-30	11-Jul	19-Jul	21
90-6-2	16-Jul	26-Jul	35
90-8-11	14-Jul	26-Jul	27
90-8-20	13-Jul	19-Jul	24
90-12-50	13-Jul	26-Jul	35
Chilcotin	12-Jul	26-Jul	23
Chilliwack	14-Jul	19-Jul	21
Kitsilano	19-Jul	26-Jul	27
Meeker	17-Jul	26-Jul	26
Qualicum	14-Jul	19-Jul	35
Tulameen	17-Jul	26-Jul	32
97 planting			
86-6-15	3-Jul	18-Jul	33
87-18-7	19-Jul	31-Jul	30
89-2-89	19-Jul	1-Aug	30
89-6-12	10-Jul	21-Jul	28
89-6-13	12-Jul	29-Jul	36
89-33-84	9-Jul	22-Jul	31
89-34-41	10-Jul	26-Jul	33
90-4-48	13-Jul	23-Jul	29
90-8-20	12-Jul	22-Jul	26
91-15-40	13-Jul	27-Jul	33
92-4-18	9-Jul	26-Jul	39
92-5-1	14-Jul	27-Jul	29
92-5-52	12-Jul	26-Jul	32
92-9-12	19-Jul	29-Jul	25
92-9-39	6-Jul	22-Jul	38
92-10-27	12-Jul	26-Jul	29
92-10-53	11-Jul	21-Jul	32
OSU 1025-10	22-Jul	3-Aug	33
OSU 1072-11	12-Jul	22-Jul	29
OSU 870R-12	6-Jul	19-Jul	32
WSU 1024	16-Jul	29-Jul	30
WSU 1066	12-Jul	19-Jul	29
WSU 1067	19-Jul	26-Jul	22
WSU 1068	2-Jul	17-Jul	33
WSU 1082	12-Jul	22-Jul	26
WSU 1090	19-Jul	29-Jul	29
WSU 1096	4-Jul	19-Jul	32
WSU 1097	10-Jul	21-Jul	32
WSU 1098	11-Jul	19-Jul	30
WSU 1099	15-Jul	29-Jul	36
Caroline	30-Jun	19-Jul	55
Chilliwack	13-Jul	22-Jul	24
Coho	9-Jul	22-Jul	29
Malahat	4-Jul	17-Jul	37
Maryland	6-Jul	15-Jul	29
Meeker	15-Jul	29-Jul	30
Qualicum	14-Jul	24-Jul	27
Tulameen	14-Jul	25-Jul	35
LSD 5%	6	6	8

Clone	First harvest (date)	50% harvest (date)	Harvest Duration (days)
96 planting			
86-6-15	13-Jul	23-Jul	26
86-7-21	19-Jul	3-Aug	29
87-2-49	12-Jul	19-Jul	29
87-3-37	15-Jul	26-Jul	36
87-5-1	19-Jul	30-Jul	29
87-9-6	15-Jul	26-Jul	33
87-12-11	15-Jul	29-Jul	29
87-12-32	15-Jul	26-Jul	29
87-14-16	19-Jul	3-Aug	32
87-14-20	14-Jul	28-Jul	31
87-14-35	22-Jul	3-Aug	29
87-18-7	20-Jul	1-Aug	33
89-33-84	15-Jul	27-Jul	30
89-34-41	16-Jul	28-Jul	32
90-1-42	15-Jul	22-Jul	26
90-2-57	15-Jul	26-Jul	33
90-4-23	12-Jul	19-Jul	36
90-5-30	12-Jul	19-Jul	32
90-8-11	15-Jul	29-Jul	33
90-11-44	19-Jul	3-Aug	32
Beskid	19-Jul	9-Aug	39
Chilcotin	15-Jul	29-Jul	40
Chilliwack	14-Jul	25-Jul	26
Comox	15-Jul	26-Jul	26
Elida	9-Jul	19-Jul	32
Encore	6-Jul	19-Jul	29
Glen Ample	19-Jul	3-Aug	36
Glen Clova	12-Jul	22-Jul	43
Glen Magna	22-Jul	6-Aug	33
Glen Moy	9-Jul	22-Jul	35
Glen Prosen	19-Jul	3-Aug	36
Glen Rosa	15-Jul	29-Jul	29
Glen Shee	19-Jul	29-Jul	32
Haida	15-Jul	26-Jul	33
Kitsilano	19-Jul	4-Aug	33
Malahat	12-Jul	25-Jul	37
Meeker	18-Jul	31-Jul	28
NZ8724wd10	9-Jul	21-Jul	32
NZ8724wf 9	15-Jul	26-Jul	36
Nootka	12-Jul	22-Jul	36
Prelude	30-Jun	22-Jul	41
Qualicum	15-Jul	25-Jul	27
Skeena	15-Jul	22-Jul	26
Tulameen	16-Jul	28-Jul	35
Willamette	12-Jul	22-Jul	29
LSD 5%	6	6	8

Table 3. Fruit traits of raspberry cultivars harvested in 1999, Abbotsford, B.C.

Clone	Botrytis - incited fruit rot after 48h (%)	Firmness[y] (g/cm^2)	Soluble solids[x] concentration (%)
86-6-15	10.6 d-f	221 b-e	11.2 ab
87-14-20	21.1 a-e	201 b-f	10.2 ab
87-18-7	32.5 ab	192 c-g	10.6 ab
89-2-89	36.6 a	197 c-f	9.7 ab
89-6-12	13.3 b-f	207 b-f	9.1 b
89-33-84	10.6 d-f	271 a-c	9.2 b
89-34-41	18.9 a-f	189 c-g	10.5 ab
90-4-48	26.7 a-e	191 c-g	9.7 ab
90-5-30	25.0 a-e	-	-
90-6-2	-	290 ab	10.4 ab
91-15-40	30.8 a-c	216 b-e	10.9 ab
92-4-18	11.7 c-f	305 a	10.4 ab
92-5-1	11.7 c-f	206 b-f	9.2 b
92-5-52	16.7 b-f	202 b-f	9.3 b
92-9-39	8.3 ef	212 b-e	10.3 ab
92-10-53	27.5 a-e	175 d-g	10.0 ab
Coho	18.3 a-f	-	-
Chilliwack	9.4 d-f	238 a-d	12.1 a
Kitsilano	16.7 b-f	227 a-e	9.4 b
Malahat	18.9 a-f	221 b-e	11.3 ab
Meeker	28.9 a-d	181 c-g	11.1 ab
NZ 87-24WD10	13.9 b-f	196 c-f	9.9 ab
Nootka	17.8 b-f	143 e-g	12.0 a
Qualicum	17.8 b-f	260 a-d	11.3 ab
Tulameen	25.6 a-e	227 a-e	10.9 ab
WSU 1068	25.0 a-e	215 b-e	9.9 ab
WSU 1098	1.7 f	113 g	10.8 ab
WSU 1099	-	120 fg	9.6 ab
Willamette	9.3 d-f	274 a-c	9.8 ab

Mean separation within columns by SNK multiple range test at 5% level.

[y]Firmness, the force required to close the opening of the fruit, was obtained for 10 fruit from four harvests.

[x]Means of 10 fruit from four harvests.

Project No:

Title: **Red Raspberry Cultivar Development for the Pacific Northwest**

Year Initiated: 1999 **Current Year:** 2000 **Terminating Year:** 2003

Submitted by: Chaim Kempler and Hugh Daubeny
Pacific Agri-Food Research Centre, Agriculture and Agri-Food Canada,
PO Box 1000, Agassiz, BC, Canada V0M 1A0
Tel.: (604) 796-2221 ext 224; Fax: (604) 796-0359
Internet: KEMPLERC@EM.AGR.CA

Funding: 1999

Funding requested in 2000: US $7,000. The Washington Red Raspberry Commission (WRRC) contribution could be matched by Agriculture and Agri-Food Canada's Matching Investment Initiative (MII) fund with up to CD$10,000. This proposal will also be also submitted to the Lower Mainland Horticultural Improvement Association (LMHIA), the B.C. Raspberry Growers Council, and the Oregon Raspberry and Blackberry Commission (ORRC).

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 disease and pest resistance such as resistance to raspberry bushy dwarf virus (RBDV), fruit rot, root rot and raspberry mosaic virus (RMV).

The RMV complex can be a limiting factor in raspberry production. However, it can be controlled by resistance to the aphid vector. Reaction to the aphid vector *(Amphorophora agathonica)* of the RMV is used by the Pacific Agri-Food Research Centre (PARC) program as a primary screen in the seedling stage. Most of the cultivars that are released from this program are resistant to the common biotype of *A. agathonica*. A resistance-breaking biotype of *A. agathonica* has been found in North America and this has complicated the screening procedure. There is a need for genes that are resistant to resistance-breaking aphid biotype, or more universal resistance genes to RMV need to be identified. 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. The common strain of the RBDV virus has been controlled by breeding for resistant cultivars of cultivars released from the program in the past. Haida is resistant to RBDV and Nootka, although not known to be resistant, never tested positive to RBDV and likely has very good tolerance and does not get infected with the virus.

The PARC breeding program is using selection of *R. strigosus* as new sources of resistance to the root rot caused by *Phytophthora fragariae*. F1 to F3 are tested and used in back crosses to incorporate resistance into cultivars and advance selections.

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

The PARC breeding program has emphasis on broadening the genetic base by using parents that were derived from various species. Germplasm from other breeding programs around the world is used. This germplasm is tested and used to incorporate desirable traits. Also, a wide range of wild species is used. The last four cultivars released Tulameen, Qualicum, Malahat and Kitsilano, have the black raspberry, *Rubus occidentalis* L., in their derivation. In addition, 'Malahat' has *R. phoenicolasius* Maxim and Kitsilano has *R. crataegifolius* in its derivation.

Objectives:

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

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

Procedures:

Experimental Details:
This will involve harvesting of sound and rotted fruit, fruit firmness determinations with a pressure gauge, postharvest rot determinations, soluble solid and acidity determinations, evaluation of frozen samples, observations of various pests and diseases under field conditions. Seedlings will be screened for aphids and advance selections for root rot resistance.

Evaluation of all selections in the test plots at the Abbotsford Sub-Station will be continued. The evaluation in the test plots will include yield and fruit quality determinations and reactions to various pests and diseases, including fruit rot, cane disorders, aphids (which vector the mosaic

virus complex) and raspberry bushy dwarf virus, root rot (*Phytophthora fragariae)*. Any winter damage will be recorded relative to the standard cultivars, Meeker, Chilliwack and Tulameen.

Most of the advanced selections, are backcross derivatives of *Rubus strigosus*. Some of these appear to have resistance to the resistance-breaking aphid biotype and thus should prevent spread of the raspberry mosaic virus complex by the biotype; they will also be useful in further breeding studies to develop a broad base of resistance.

Activities:

- Year 2000 crossing blocks
  - continue backcross on the F1 to F3 rot root resistance selections.
  - new sources for RBDV resistance.
  - improve productivity and fruit quality.
- Evaluation of seedling population (approx. 7,000)
- Establish advanced replicated trials to assess advanced selections suitable for processing and machine harvest.
- Establish advanced replicated trials to assess advanced red raspberry selections.
- Evaluation and propagation of advanced selections.
- Supervise distribution of advanced selections to North American propagators, growers and subsequently monitor their performance.

Anticipated Benefits and Information Transfer:

The results of the evaluations will be directly available to the red raspberry industry in North America. In the coming year the evaluations will help determine if selections like BC87-14-20, BC89-2-89, BC89-6-12, BC89-33-84, BC89-34-41, BC90-1-42, BC90-2-45, BC90-4-23, BC90-5-30, BC90-6-2, and others are commercially suitable.

Budget:

Amount requested from the Commission for FY 1999-2000: US$ 7,000.

The WRRC contribution could be matched by Agriculture and Agri-Food Canada's MII fund with up to CD$ 10,000.

Resource commitments (CD$): (for each year between April 2000- March 2003):

Research assistance	$ 30,200
Summer students (4 x $7,500)	$ 30,000
Land preparation (fertilizer, field fumigation, etc.)	$ 7,000
O&M (drip irrigation, trellis, etc.)	$ 4,800
Travel	$ 3,000
Total	**$ 75,000**

Other collaborative partners:

Lower Mainland Horticultural Improvement Association
B.C. Raspberry Growers Research Council
Oregon Raspberry and Blackberry Commission

Project No.: 13C-3761-3640

Title: Use of gypsum to control Phytophthora root rot in established red raspberry plantings.

Reporting Period: 1999

Personnel: Peter R. Bristow, Associate Plant Pathologist, WSU-Puyallup Research and Extension Center
Stephen F. Klauer, and Chuhe Chen, Research Associates and J. Scott Cameron, Superintendent and Asst. Dean, WSU-VancouverResearch and Extension Unit

Accomplishments: Gypsum was broadcast onto the soil in the alleyway and then tilled in before the soil was thrown up around the base of plants to rebuild raised beds in fall 1998. Tilled soil from the alleyway without gypsum served as the untreated check. Experiment A: Data on the growth of primocanes arising from established plants was collected in 1999. Experiment B was started in an area where the original plants died from root rot. Raised beds in this area, with and without gypsum, were replanted with certified plants in spring 1999. Plant growth will be measured in late fall.

Results: Experiment A – Adding gypsum to the soil used to rebuild raised beds nearly doubled the number of primocanes per plot. Primocanes in treated plots were the same length as those in untreated plots. There was no apparent impact of gypsum on fruiting canes in 1999 but this was expected as these canes were present before gypsum was applied in fall 1998.

Experiment B – New plants were set out in spring 1999 in areas where the original plants died from root rot. Some new plants went into gypsum-treated soil and the remainder went into untreated soil. Nearly all of the new plants survived and cane growth measurements will be taken in early November.

Appendix

Table 1. Primocane length and number for established plants in plots with and without gypsum.

Treatment	Primocane, no. per plot	Primocane length, cm
No gypsum	56.7	204
Gypsum	95.3	204
Pr>F	0.0001	0.9488

Project No.: 13C-3761-3640

Title: Use of gypsum to control Phytophthora root rot in established red raspberry plantings.

Year Initiated: 1999 **Current year:** 2000 **Terminating Year:** 2002

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

Justification: Root rot caused by the soil-borne fungus *Phytophthora fragariae* var. *rubi* is the most serious root disease of red raspberry. When Ridomil was first tested, plantings could be restored to productivity because the fungicide protected the remaining healthy portions of the root system allowing plants to re-grow and protected the new root and cane growth. In recent trials at the WSU-Vancouver Research and Extension Unit, it has been difficult to establish new plants in Ridomil treated soil. Other approaches to controlling this devastating disease are being studied. Researchers in New York State demonstrated that amending soil with a high rate of gypsum before planting suppressed the disease. That research was repeated here in Washington and after two years, disease control in gypsum treated plots continues to look very good. It appears that gypsum is tool to be used in an integrated control program. In this project, we want to find out if gypsum can be applied to established plantings with similar results. The planting used for this project was established (spring 1997) on raised beds but they have settle and eroded to the point where the top of the beds is only 6-9 inches above soil in the alleyway between rows. Beds need to be maintained about 12 inches high for the soil to remain dry enough to suppress activity of the fungus. Some growers re-build beds by throwing soil from the alleyway up around the base of plants in the fall. Other growers have created raised beds or ridges from flat plantings by the same technique. As new primocanes push up through the added layer of soil roots grow from underground portion of those canes into that layer. If gypsum could be incorporated in to that layer of soil, those new roots might be protected from the pathogen.

Objectives:

1. To determine if established plants can be protected by gypsum that is mixed with soil used to re-build existing raised beds.

2. To determine if re-plants can be protected by gypsum when they are planted into gypsum amended soil that has been used to re-build existing raised beds.

Procedures: Experiment A. A planting established on raised beds in spring 1997 was used for this experiment. Agricultural gypsum was mixed with the soil in the alleyway before it is thrown up around the base of existing plants in fall 1998 to restore the raised bed to is original height. Areas without gypsum will serve as the untreated check treatment. Approximately six inches of soil were added to the raised bed. The two treatments will be repeated annually to maintain the height of the raised beds at 12 inches. Root rot severity (percent wilted primocanes, fruiting cane collapse and plant survival) will be assessed each growing season as will plant growth (number and length of healthy primocanes, etc.) and yield (plots to be harvested by hand). As part of the integrated disease control program used on the entire planting, all plots will be treated with Ridomil and Aliette according to label directions.

Experiment B. This experiment will be very similar to Expt. A, except than areas in the field where plants died in 1998 will be used. Existing raised beds will be re-built in fall 1998 using soil with and without gypsum. The areas will be replanted in spring 1999 with Meeker plants and plant growth and survival will be followed during the establishment year. Disease severity and plant growth and yield will be recorded in subsequent years.

Anticipated Benefits and Information Transfer:
Benefits: Controlling this serious root rot will require an integrated approach. Several of the approaches are best implemented when a new field is planted. Remedial treatment(s) for established plantings is more difficult, but the growth habit of the red raspberry plant appears to allow for some flexibility. The root system of the plant can be moved upwards in the soil profile by mounding soil around the base of plants. If high rates of gypsum can be incorporated into the soil used to create or maintain raised beds then it may be possible to protect new roots that grow in the bed. Even at high rates, gypsum is relatively inexpensive and because it dissolves slowly, it most likely will not have to be applied every year. Data from other trials show that the beneficial effects of gypsum do last more than a single season.

Information/Technology Transfer:
Information from this project will be disseminated at local and regional grower's meetings and at field days. It will be incorporated into WSU Cooperative

Extension publications when appropriate. The results will be combined with results from other research for publication in scientific journals.

Budget:

Amount allocated by commission for FY 1999-2000: $2450

Request for FY 2000-01	
Timeslip labor	$1,300
Operations (goods and services)	700
Travel	
Projected needs	200
Meetings	142
Equipment	0
Employee benefits	208
Total	$2550

Project No.: 13C-3761-4640

Title: Field evaluation of new fungicides for control of gray mold fruit rot (*Botrytis cinerea*)

Reporting Year: 1999 (Terminal report)

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

Accomplishments: Nine different fungicide treatments were compared with one another and to a water check for control of gray mold fruit rot (*Botrytis cinerea*) in a replicated trial conducted in a commercial 'Meeker' field west of Lynden, WA. Plots treated with Switch and Elevate out yielded those of the water check by 24 and 14%, respectively. The marked increase in yield was due mainly to the control of gray mold. Both of these new fungicides also reduced the incidence of fruit rot developing in two types of post harvest rot tests and extended the shelf life of fresh berries. Captan, Benlate, Rovral, Serenade (a biological control material), Zerotol and a standard program (Benlate, Captan and Rovral alternated or tank mixed in various combinations) had little impact on yield or the incidence of rot in the post harvest tests. The lack of performance with Benlate, Rovral and the standard program in this trial plus laboratory data (from 1998) showing that many isolates of *Botrytis cinerea* from red raspberry fields are no longer sensitive to these products provides further evidence that resistance to these currently registered fungicides is widespread.

Results: The results from the field trial document the level of disease control growers achieved using Switch which was cleared for use in 1999 under a Section 18 emergency exemption.

Many of the berries that rotted were attacked when they were still green. These berries shriveled and dried on the receptacle and were not shaken loose by the harvester. After harvest, fruiting laterals were collected from every plot and each fruiting position was examined to account for rotten berries that remained on the plant. We just finished collecting this data and it has not been summarized yet. Other infected berries ripened and mold developed on only a few druplets. Growers refer to this type of mold as "spot rot". Berries with "spot rot" are removed by the harvester. We were not able determine the incidence of spot rot in machine harvested fruit but incidence appeared to be lower in plots treated with Switch,

Elevate, Captan and the standard program.

Treatments were included in the trial to find out if adding foliar nutrients to fungicide sprays increases the incidence of fruit diseases. We used the standard fungicide program for this experiment. Some plots received the standard program alone while others were sprayed with the standard program but with foliar nutrients added to the tank on each of the six application dates. The addition of foliar nutrients to the standard fungicide program had no impact on 1) yield, 2) incidence of fruit rot in post harvest tests or 3) lateral length. Additional data will come from the detailed examination of the collected fruiting laterals.

Cane botrytis was the most common disease on primocanes in the test plots. Based on a visual rating of the number of lesions on canes, Switch, Elevate and the standard program markedly reduce the incidence of cane botrytis. Primocanes were cut from every plot for detailed counts in the laboratory. The data has not been summarized yet.

The twospotted spider mite infested the planting in late July and by early August, damage to fruiting cane leaves was severe in some plots. Damage was most severe in plots treated with Captan and Serenade; intermediate in those treated with the standard program (with or without foliar nutrients) and least in plots treated with Rovral, Elevate, Switch, Benlate and water. When the plots were evaluated again in early September, there was more damage to fruiting canes in all plots. One reasons for field testing new products is to see if they are phytotoxic to the crop; another is to find out they impact other biological components of the crop system.

Appendix

Impact of different fungicide treatments on yield of 'Meeker' red raspberry (berries harvested with a Littau harvester). Units: grams of fruit per plot.

Treatment	Yield, grams of fruit per plot[z]					
	Harvest 1	Harvest 2	Harvest 3	Harvest 4	Harvest 5	Season Total
	July 12	July 19	July 26	August 2	August 10	
Switch	1143.3 ab[y]	2075.6 a	5535.4 a	5305.3 a	1941.4 a	16001.0 a
Elevate	1225.9 a	2021.1 a	5358.1 ab	4136.6 b	1979.8 a	14721.5 a
Water check	361.7 e	1666.0 ab	5067.6 abc	3583.5 c	2254.8 a	12933.6 b
Rovral	887.7 abcd	1696.3 ab	4649.4 bcd	3152.7 cde	1930.4 a	12316.4 bc
Captan	1058.3 abc	1674.3 ab	4259.5 cd	2760.4 e	1431.8 a	11184.2 bc
Zerotol	610.5 cde	1503.4 ab	4599.7 bcd	3445.8 cd	1768.3 a	11927.6 bc
Serenade	796.5 abcde	1628.3 ab	4181.7 d	3004.2 cde	1609.3 a	11219.8 bc
Benlate	396.6 e	1353.2 b	4663.6 bcd	3111.3 cde	1528.8 a	11053.5 bc
Stnd[w] & Fol[x]	593.9 de	1380.9 b	4450.9 cd	3054.4 cde	1516.4 a	10996.5 bc
Standard[w]	739.3 bcde	1368.1 b	4018.5 d	2835.4 de	1458.6 a	10419.9 c
Pr > F	0.0010	0.0368	0.0034	0.0001	0.5262	0.0001

[z] Plot size: 30 feet of row. The center 20 feet was harvested for yield.
[y] Duncan's Multiple Range Test (P=0.05).
[x] Fol = foliar nutrients [2.5 lb urea (46-0-0) and 3.0 lb urea (18-18-18) + Boron (1.75%)].
[w] Standard = Captan plus Rovral on Jun 3 and Jul 12; Benlate plus Captan on Jun 10 and Jul 12; Captan alone on Jun 21 and Rovral alone on Jul 22.

Rating of damage to fruiting canes leaves by twospotted spider mite on two dates.

Treatment	Damage rating for fruiting cane leaves[z]	
	Aug 2	Sep 3[y]
Serenade	2.4 a[x]	2.5 a
Captan	2.4 a	2.5 a
Standard + Fol.	1.6 b	2.4 a
Standard	1.5 b	2.3 a
Rovral	.8 c	2.1 a
Elevate	.6 c	1.7 a
Switch	.6 c	1.7 a
Zerotol	.6 c	1.9 a
Water check	.5 c	1.9 a
Benlate	.4 c	1.5 a
Pr > F	0.0001	0.0513

[z] A 0-3 damage rating scale was used (0 = little or not damage and 3 = most severe damage). Because the rating scale is relative, direct comparison between dates is not valid.

[y] All plots showed some damage on Sep 3, therefore the rating =0 was not used on this date.

[x] Duncan's Multiple Range Test (Pr=0.05).

Rating of damage and counts of twospotted spider mite (TSSM)* and a predatory mite on primocanes leaves.**

Treatment	Damage rating for primocane leaves on Sep 3[z]	No. of TSSM per leaflet on Aug 5	No. of predatory mites per leaflet on Aug 5
Captan	2.2 a[y]	1077.3 a	4.0 a
Standard.	2.2 a	526.8 a	2.0 a
Serenade	2.0 ab	803.0 a	4.2 a
Standard + Fol.	1.8 abc	786.0 a	5.2 a
Zerotol	1.7 abc	746.3 a	3.9 a
Water check	1.7 abc	676.5 a	4.9 a
Rovral	1.5 abc	605.5 a	3.6 a
Elevate	1.4 bc	591.5 a	2.3 a
Benlate	1.4 bc	459.3 a	5.9 a
Switch	1.1 c	853.8 a	5.5 a
Pr > F	0.0225	0.5210	0.6686

* *Tetranychus urticae*

** *Amblyseius fallacis*

[z] Damage rating scale: 0-3 scale where 0 = little or not damage and 3 = severe damage.

[y] Duncan's Multiple Range Test (Pr=0.05).

Disease severity rating for cane botrytis (*Botrytis cinerea*).

Treatment	Disease severity rating[z]
Rovral	2.4 a[y]
Water check	2.3 a
Serenade	2.2 a
Captan	2.1 a
Benlate	2.1 a
Standard	2.1 ab
Zerotol	2.1 ab
Standard + Fol.	1.5 bc
Elevate	1.1 c
Switch	1.1 c
Pr > F	0.0001

[z] DSR = Disease severity rating: 0-3 scale where 0 = no disease and 3 = severe damage.
[y] Duncan's Multiple Range Test (Pr=0.05).

Project No.: New

Title: Soil solarization as a method for preparing soil infested with *Phytophthora fragariae* var. *rubi* for planting.

Year Initiated: 2000 **Terminating Year:** 2002

Personnel: Peter R. Bristow, Associate Plant Pathologist, WSU Research and Extension Center-Puyallup
Jack Pinkerton, Research Plant Pathologist, Horticultural Crops Research Laboratory, USDA-ARS, Corvallis, OR

Justification: Root rot caused by the soil-borne fungus *Phytophthora fragariae* var. *rubi* is a serious root disease of red raspberry and it has been especially difficult to control. The cultivar 'Meeker', grown on 80% of the red raspberry acreage in the Pacific Northwest, exhibits some field tolerance once it becomes established but is susceptible when young. 'Willamette', the second leading cultivar is also susceptible. Plant breeders in this region have been frustrated in efforts to combine useful levels of resistance and acceptable horticultural traits. Ongoing research is developing an integrated approach to control where several cultural and chemical practices will be combined to achieve satisfactory control. Whatever practices are combined, it is critical that young plants establish strong root systems during the initial year of growth. Several researchers have shown that covering well tilled soil with a clear polyethylene tarp and letting the soil heat up during the sunniest time of the year reduced nematode populations, weed seed numbers and damage caused by a wide range of soil-borne fungi. Soil solarization has been discounted for areas in Washington and Oregon west of the Cascade Mountains because of its maritime climate. However, field studies conducted near Corvallis, OR in the summer of 1995 demonstrated that soil temperatures in solarized plots to a depth of 1 ft were high enough to reduce pest populations.

Objectives:

1. To determine if solarizing soil naturally infested with *Phytophthora fragariae* var. *rubi* will reduce damage from root rot when red raspberries are planted into solarized soil

2. Compare he performance of plants grown in solarized soil to those treated with Ridomil Gold and if the combination of the two will further improve disease control.

Procedures: This project was initiated in July 1998 at the WSU-Vancouver Research and Extension Unit, when twelve plots (each 10 ft X 30 ft) were covered with clear polyethylene tarps and 12 plots were left uncovered. Tarps were left in place for 8 weeks. Soil temperature was recorded continuously during this period at two depths in both covered and uncovered plots. Soil samples were collected from each plot both before and after solarization for use in growth chamber studies. Ditches were dug around the solarized plots so winter rains would not wash soil from the non-solarized plots into those that had been solarized. In April 1999, the soil was rotovated and tissue culture propagated plants of two root rot susceptible cultivars (Qualicum and Skeena) were planted on April 22 and May 21, respectively. In all field activities, care is taken not to contaminate soil in the solarized plots. The following four treatments were replicated in the planting: 1) untreated check (non-solarized soil, 2) non-solarized soil and plants treated with Ridomil Gold at planting and then each fall and spring, 3) solarized soil and 4) solarized soil plus Ridomil Gold. Irrigation or rain is used to wash Ridomil Gold into the soil after each application. Data on plant survival, disease incidence and severity will be collected over the next 2 years.

Results:
Tissue culture propagated plants (Qualicum) were grown for 8 weeks in soil collected from all plots before solarization and from both covered and uncovered plots after solarization. The soil was kept at 55 F and near saturation to increase disease pressure. The root system of plants grown in solarized soil was significantly the larger (dry weight) than that of plants grown in either non-solarized soil or soil collected before solarization. Roots of plants from the pre-treatment soil and the uncovered plots were darker in color than those from solarized soil. This preliminary information suggests that heating the soil may be useful in reducing damage from root rot.

Anticipated Benefits and Information Transfer:
Benefits: Controlling this serious root rot will require an integrated approach. Several of the approaches are best implemented when a new field is planted. Information from this field trial will determine if soil solarization is a useful technique for reducing damage in new plantings and how long benefits from solarization will last.

Information/Technology Transfer:
Information from this project will be disseminated at local and regional grower's meetings and at field days. It will be incorporated into WSU Cooperative Extension publications and the PNW Plant Disease Control Handbook when and

if appropriate. The results will be combined with results from other research for publication in scientific journals.

Budget:

Request for FY 2000-01

Timeslip labor	$300
Operations (goods and services)	800
Travel	400
Meetings	75
Employee benefits	50
Total	$1,625

Other support of the project:

Technical support, vehicle use, etc. from USDA comes through Dr. Pinkerton's project.

Project No.: New

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 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:
In cooperation with the two nurseries that produce certified planting stock, a total of 10 acres will be surveyed in this pilot project. The procedures outlined here are preliminary and will likely be modified as discussions with cooperators and WSDA personnel continue. Most of the acres included in the study will be planted in the spring with plants and roots being dug in the fall. Some of the acres will be planted in the fall with tissue culture propagated plants and harvested the following fall. A portion of the acres will be replanted on a short rotation with little fallow time between successive red raspberry crops while other will be on a long rotation with several years between red raspberries for certified plant production. Fields will be fumigated before planting according to rules in the certification scheme.

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 blocks based on how roots will be dug. A root sample will come from one randomly selected plant in each block. 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 (the possibility of using a GPS system for mapping is being explored). 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 25 additional samples 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 do not know from which farm, field or sampling site any given sample was collected.

Each acre produces about 100 boxes (500 plants per box) of No. 1 plants. Plants dug from two acres at each nursery will be tracked through the cleaning, sorting bundling and boxing process and then one root sample from each box will be tested. Boxes from which coded root samples were collected will be marked for

re-sampling if the original sample tests positive. The results from field samples will be compared with those from box samples.

Selected fields will be surveyed again when they are planted back to red raspberries for certified plant production. Fields with short (0-1 year) and long (3-5 year) rotations will surveyed a described above.

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 2000-01	
Timeslip labor	$3,500
Operations (goods and services)	4,700
Travel	
Projected needs	200
Meetings	250
Equipment*	300
Employee benefits	560
Total	$9,510

* Rental of GPS equipment

Other support for the project:

None

Title: Towards development of a sex attractant pheromone for control and monitoring of the raspberry crown borer, *Pennisetia marginata* (Lepidoptera: Sesiidae)

Year Initiated: 1997 **Current Year:** 2000-2001 **Terminating Year:** 2002

Personnel: Jeremy J. Heath, Graduate Research Associate
Roger N. Williams, Professor of Entomology
P. Larry Phelan, Associate Professor of Entomology and Chemical Ecology
Ohio Agricultural Research and Development Center/Ohio State University
Department of Entomology
1680 Madison Ave
Wooster OH 44691

Collaborators: David G. James, Assistant Professor of Entomology
Irrigated Agricultural Research and Extension Center/ Washington State University
Department of Entomology
24106 N Bunn Road
Prosser, WA 99350

Lynell K. Tanigoshi, Associate Professor of Entomology
Vancouver Research and Extension Unit/ Washington State University
1919 NE 78th Street
Vancouver, WA 98665

Justification

Recently, the EPA has classified diazinon and azinphos-methyl as "restricted use" pesticides for use on small fruits including caneberries. This requires that the product be applied by or supervised by a certified pesticide applicator. Previously, bramble growers would drench the crown and lower parts of the cane with one of these pesticides in the fall or early spring, which would kill some of the first instar larvae in their overwintering chambers. Now growers are stuck without a method of control unless they hire or become certified. However, even diazinon only yields moderate to low control and only after a couple years of treatment.

It is safe to say that the EPA will continue to put pressure on farmers to reduce the use of broad-spectrum pesticides and increase the use of environmentally benign control tactics; therefore, being proactive and establishing alternative control methods now will prepare growers for the near future, as well as benefit them in the present.

Identification of the sex attractant pheromone for this insidious pest will allow efficient, sensitive monitoring and subsequent mating disruption in problem areas. Although some workers have found the RCB males to be attracted to (*E,Z*)-3,13-octadecadiene-1-ol (Brown and Snow 1985 and Solomon et al. 1982) it is certainly not the complete blend and is much less attractive than a virgin female (Williams unpublished). To our knowledge we are the only group presently working on this pest. This is not because it is not economically important, but because it is very cryptic and obtaining adults is challenging and labor intensive. However, we have developed a method of collection that completely eliminates these difficulties.

Objectives

(1) The primary objective of this proposal is to identify the chemical components of the female-based raspberry crown borer (RCB) sex pheromone.

(2) Field test candidate compounds for efficacy at different ratios.

(3) Field test various release devices and traps for efficacy in monitoring populations.

(4) Establish economic injury levels and thresholds with previously optimized trap and release device .

(5) Optimize mating disruption by testing various active and passive release devices (e.g., puffers, rubber septa, etc.).

Objectives one and two will be addressed this funding year.

Procedures

Insect collection. Several sesiid sex pheromones have been identified; however, the pheromone of the RCB has eluded researchers mainly because of the pest's cryptic nature. The majority of moth pheromones identified to date have been of species that could be reared throughout the year, in the laboratory, yielding hundreds of individuals for chemical analysis. Unfortunately, this is more complicated with the RCB. Females must be collected from the field utilizing a very labor intensive procedure, during a narrow window of time.

In the past, this has severely limited the number of individuals available for analysis. However, this past season (fall 1999) we made significant strides in the pheromone identification, mainly because we had a large supply of individuals. These were obtained from the public. We paid individuals to collect pupae from wild populations. This program was much more successful than we had anticipated and we received a sufficient supply of pupae. We also received considerable attention from the press (we made the front page of two of the largest newspapers in Ohio), which undoubtedly contributed to our success. We plan to use this same program next year, but expand it to include all states. Additionally, we will obtain males from traps baited with field-collected and laboratory-emerged virgin females. In the 1997 field season we caught 19 males with one virgin female in one day, despite the fact that it was toward the end of the emergence period. This further illustrated the power of the pheromone as well as its potential for monitoring.

Chemical Analysis. An active component of the RCB pheromone is (*E,Z*)-3,13-octadecadiene-1-ol (E3,Z13-18:OH). Preliminary studies have illustrated that this compound is not an effective male attractant alone; therefore, the complete pheromone blend likely contains other unidentified compounds. Coupled GC-EAD (gas chromatograph coupled with an electroantennographic detector) analysis of virgin female extracts in the 2000 field season will allow the determination of

active compounds which will be subsequently identified with GC-MS analysis. This is a commonly used technique to elucidate and identify active components of a sex pheromone. In the fall of 1999 we identified several EAG-active chromatographic peaks and plan to structurally identify and synthesize these compounds for field testing.

Field testing candidate compounds. Potential pheromone components will be synthesized during the winter months of 1999 and 2000 and tested in the field in Washington, Ohio, and possibly Oregon. Wing traps baited with pheromone-impregnated septa will be placed in the field and re-randomized every 4-5 days to negate positional effects. Results will be analyzed with an ANOVA followed by linear or polynomial contrasts to separate means.

Optimizing trap catch. There will likely be two main components in the pheromone blend. Once these are determined by GC-EAG and field testing, various ratios of the components will be field tested as described above. We will test from 100% component A and 0% component B to 100% component B and 0% component A at 10% intervals as described in Cowles et al. (1996).

Once the ratio is optimized, we will test the following Pherotech trap types for efficacy: wing traps with removable inserts and with 3 different spacer sizes, unitraps, delta traps (open and closed), and 4- and 8-funnel Lindgren funnels. Similar field testing techniques will be used.

Establishing an economic injury level. With an optimized trap we will establish an economic injury level and control threshold. Populations will be accessed in the fall and correlated with damage the following year. A complete description of the methods is beyond the scope of this proposal, however.

Optimizing mating disruption. Various release devices have been designed to affect mating disruptions. These include "puffers", which are timed aerosol release canisters. These canisters would last the entire season and maintain a constant level of pheromone in the air. Unlike the passive release devices, the canisters can be timed to release pheromone only during the active period of the pest, thus conserving valuable compound. We will test these canisters as well as passive release devices, such as rubber septa and wire ties.

Anticipated Benefits and Information Transfer

Once identified, the pheromone would be synthesized and used to bait traps for monitoring purposes. The traps would provide valuable data concerning the pest's phenology, timing of control tactics, and the development of economic injury levels and thresholds. In addition to monitoring, the sex pheromone will be useful in controlling the pest through mating disruption. Since the RCB is very cryptic, many growers do not make the connection between this pest and reduced vigor and yield. Therefore, a monitoring system, at the very least, would make potential damage by the RCB more apparent and alert growers early that they have a problem before populations rise too high.

Traps and pheromone bait will be available to growers through several suppliers and extension services will be used to alert the growers to the new tools once they are developed.

Budget:

Amount allocated by Commission for FY 1999-2000: $0

Requested for FY 2000-2001:	$2828
Salaries:	$0
Time-slip:	$800
Operations:	$1300 (to pay collectors)
Travel:	$250
Projected Needs:	$0
Meetings:	$0
Other:	$100
Equipment:	
traps and lures	$250
Employee Benefits:	$128 (16% of time-slip)

The travel and time-slip requests are to support travel and labor associated with the WSU field sites, which will be checked and re-randomized weekly throughout the study period. Traps and lures will be purchased with the equipment funds. These wing traps are necessary to measure the moth response to the various test compounds.

Other support of project:

OARDC transportation, lab and equipment, salary of PIs, graduate associate, and assistants paid by OARDC/OSU. We also typically receive about $2000 annually from the Ohio Vegetable and Small Fruit Research & Development Program. This year, we also intend to seek support and cooperation from Oregon researchers and growers.

We need additional support from your commission mainly to pay our pupae collectors. In 1999 we spent about $2600 paying collectors. We are requesting half this amount in the operations section. We will request the other half and more from Ohio and Oregon growers. Since obtaining enough pupae for chemical analysis is the major limiting factor in the identification of this pheromone, we feel justified in paying a fair amount for pupae. Further, it is an excellent and profitable interaction with the public.

References

Solomon, J.D., F.L. Oliveria, J.H. Tumlinson, and R.E. Doolittle. 1982. Occurrence of clearwing borers (Sesiidae) in west central Mississippi. *J. Georgia Ent. Soc 17:* 4-12.

Brown, L.N. and J. W. Snow. 1985. The blackberry clearwing borer, *Pennisetia marginata* (Harris): a first report in Florida. *Florida Entomologist 68:* 699.

Cowles, R.S., J.G. Millar, E.J. Perry, J. S. McElfresh, and N. Garrison. 1996. Indentification of the sex pheromone of the western poplar clearwing moth (Lepidoptera: Sesiidae). *Environmental Entomology 25*(1): 109-113.

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
DG James	Current: Wine Advisory Board	$35,000	July 2000	30%	IPM of grape pests
	WA Hop Comm.	$47,000	July 2000	30%	IPM of hop pests
	Hop Research Council	$43,000	July 2000	40%	IPM of hop pests
DG James	Pending: NCSFR	$ 40,000	Jan 2000 – Dec 2000	25%	Development of mating disruption for currant borer

9/15/99

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
R.N. Williams	Current: Ohio Grape Ind. Committee	25,000	July1 - June 30 1999 2000	35 %	-Developing an Integrated Peat Management System for Insect and Mite Pests in Ohio Vineyards.
R.N. Williams & P. Grewal	Cornell Univ./USDA	15,000	July1 - June 30 1999 2000	20%	-Development of rearing techniques and biological control methods for the grape root borer, *Vitacea polistiformis*
R.N. Williams J. Heath P.L. Phelan	Ohio Vegetable & Small Fruit Res. & Dev. Program	2,800	Jan. 1, 1998 – Dec. 31, 1998.	10%	-Development of a sex attractant for control and/or monitoring of the raspberry crown borer, *Pennisetia marginata*
R.N. Williams	Ohio Fruit Grower's Society. $1,000	1,500	Jan.1 – Dec. 31, 1999	15%	-Survey of Pollinators in a Commercial Strawberry Planting.
R.N. Williams & M.A. Ellis	USAID/Wash.	11,932	Sept. 29, 1999 – Sept. 28, 2000.	10%	-IPM CRSP/Ecuador --- Integrated Pest Management Collaborative Research Support Program.
R.N. Williams & M.A. Ellis	USAID/Wash.	21,700	Sept. 29, 1999 – Sept. 28, 2000	10%	-IPM CRSP/Ecuador 3 Projects: Andean Fruits; Potato Late Blight; Cooking Bananas (Plantain):

Grewal, P.S., Klein, M.G., Williams, R.N.	Pending: NorthCentral Sustainable Agri. Research & Edu. Comp.Grant Prog.	35,000	Jan. 1, 2000 - Dec. 31, 2000		-Multi-media aids and inservice training program for using insecticidal nematodes.
Roger Williams & James Tew.	North American Strawberry Grower's Assoc.	3500	Jan. 1, 2000 - Dec. 31, 2000		-Survey of the Pollinators of Strawberries and Determine Pesticide tolerances for the Honey Bee, *Aphis mellifora*.
R.N. Williams & D.S. Fickle & M.E. Ellis	Ohio Div. of Wildlife and the Ohio Biol. Survey.	33,000	Jan. 1, 2000 - Dec. 31, 2002		-A Comprehensive Survey of the Sap Beetles (Nitidulidae) of Ohio

A:instructions00/cp2/cm
9/99

Title: Development of Resistance to- and Epidemiology, Detection, and Management of Tomato Ringspot Virus and *Xiphinema americanum* in Red Raspberry.

Year Initiated 1999 **Current Year** 2000-2001 **Terminating Year** 2004

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. Phone 514-750-8794, FAX 514-750-8764, E-mail pinkertj@bcc.orst.edu, martinrr@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.

Objectives:

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 want to be able to monitor changes in virus content in the nematode population and to a develop 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. in 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 aquisiution, transport, and inoculation of TomRSV in a raspberry planting. Leaves and roots of primocane and florocanes 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.

Develop raspberry plants via genetic engineering that contain the coat protein of TomRSV. These plants will be planted at a site with a high level of *Xiphinema americanum*, that are vectors of TomRSV. The plants will be monitored for field resistance to TomRSV. We are working with the cultivar 'Meeker' for this project at the present time. Once the technology is proven it should be adaptable to any cultivar.

1999 - Field plots were established. Sampling and assay protocols for the nematode and the virus are being developed. The decrease of nematode-borne virus in the soil is being monitored under different management options through the year.

Specific objectives for 1999-2000

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. Elucidate the spatial-temporal processes of tomato ringspot virus spread in red raspberry as a bases for the development of disease management strategies. This will involve the movement of TomRSV within raspberry plants and movement via nematodes between plants.
4. Transform raspberries with construct containing coat protein of TomRSV.

2000. Establish field plots with TomRSV transgenic raspberries in infested site. Field plots will be planted with raspberries. Reinfection of plants will be monitored. Plots will be established to study the spread of TomRSV from discrete foci in a raspberry planting. The seasonal distribution of the virus in the nematodes and plants will be monitored.

2001-2003. The same parameters will be monitored as in 2000. The research data will be analyzed and summarized for the small fruit industy and manuscripts

will be prepared for publication. Monitor transgenic plants for infection by TomRSV, trueness to type, fruit quality.

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 resistance in red raspberry to TomRSV.

Facilities:

All facilities for this project exist either at the USDA-ARS Northwest Center for Small Fruits Research Facility except for the field plots which are located in Vancouver, WA. The plot area has been leased for five years from a grower where *Xiphinema americanum* and tomato ringspot virus are know to occur..

Budget: 2000

Student Labor	2150
Plasticware (ELISA plates, PCR tubes and plates)	700
Enzymes (reverse transciptases and TAQ polymerases	800
Immunofluorescence mircoscopy supplies	400
Tissue culture supplies	700
Student labor	2150
Total	4,750

Current & Pending Support

Name	Supporting Agency	Total $	Dates	% of Time	Project Title
Current					
Martin&Mathews	WA Red Rasp Comm	13,000	1999	8	Resistance to RBDV
Martin&Mathews	BC Rasp Council	13,000 (CA)	1999	8	Resistance to RBDV
Martin&Mathews	OR Rasp &Blackberry	4,000	1999	5	Resistance to RBDV
Martin	OR Wine Adv Board	7,500	1999	5	Grape virus survey
Martin&Mathews	SBIR	15,000	1999	8	Resistance to RBDV
Martin	USDA	80,000	99-2001	5	Transmission of RBDV
Martin	NWCSFR	12,000	1999	5	Virus Clean Up Program
Pinkerton&Martin	NWCSFR	7,500	1999	5	Management of TomRSV
Pending					
Pinkerton & Martin	NABGA	2,000	2000	5	Management of TomRSV
Pinkerton & Martin	OR Rasp&Blackberry	4,750	2000	5	Management of TomRSV
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 & Blackbery	4,000	2000	5	Resistance to RBDV
Martin	NWCSFR	6,000	2000	5	Virus Clean Up Program
Pinkerton&Martin	NWCSFR	10,450	2000	5	Management of TomRSV

Project No: New

Title: Caneburning and Weed Control in Red Raspberries

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

Personnel:

Timothy W. Miller, Extension Weed Scientist, WSU Mount Vernon
Stephen F. Klauer, Chuhe Chen, Research Associates, WSU Vancouver
J. Scott Cameron, Director & Ass't Dean, 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 will be established at WSU Vancouver to study the effects of Goal (oxyfluorfen), Aim (carfentrazone), and Enquik (monocarbamide dihydrogensulfate) used to control primocane growth of raspberry. Products will be applied at recommended rates and timings each spring for three consecutive growing seasons. Effect of the products on primocane suppression, weed control, and berry yield will be evaluated. Yield estimations will be accomplished by removing and analyzing four random canes per plot just before harvest. Plots will be 10 feet in length and contain three hills trained in a modified hedgerow. During each week of harvest, plots will be partially harvested in a random manner and the weight of 50 berries recorded. Yield potential will be estimated on both a per acre and per cane basis. At the end of the season, primocane numbers per plot 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.

Caneburning studies will also be conducted on grower raspberry fields near Lynden, WA. Products of interest are Goal, Finale (glufosinate) and Aim. New products of interest are Scythe (pelargonic acid) and Tough (pyridate). Tank mixtures tested in 1998 are Milestone + Gramoxone (azafenidin + paraquat), Visor (thiazopyr) + Goal, and Scythe + Goal will tested again in 2000. All products 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 resulting from caneburning treatments will be evaluated. Yield will be estimated by weekly berry picking from a 1-meter section within each 10-ft plot length through the harvest season. Total weight from the harvested sections and 50-berry weights will be recorded.

2. Perennial weed control studies will be conducted on grower raspberry fields near Mount Vernon, WA. Fall weed control products of interest are Milestone and Visor, and spring tank mixtures applied at caneburning are Milestone, Visor, Gramoxone, Goal, and Aim. 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.

Current & Pending Support

Instructions:

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

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
	Current:				
	Com. Pest. Reg.				
Miller & Libbey	10A 3143 2238	$ 3,340	7/1/99 to 6/30/00	5	Chem. control of grassy weeds in per. ryegrass grn. for seed
Miller & Libbey	10A 3143 2253	3,500	7/1/99 to 6/30/00	5	Weed control in spinach and table beets grn. for seed
Miller & Libbey	10A 3143 2254	4,525	7/1/99 to 6/30/00	5	Weed control in newly planted strawberries
Johnston, Anderson, & Miller	10A 3455 0329	44,000	7/1/99 to 6/30/99	5	Alternatives to burning of grass seed post-harvest residue
	Bulb Com.				
Miller & Libbey	13C 3419 4228	12,110	2/1/99 to 1/31/00	10	Weed control in ornamental bulbs
	Blueberry Com.				
Miller & Libbey	13C 3419 5229	4,230	7/1/99 to 6/30/00	5	Weed control in blueberries
	Strawberry Com.				
Miller & Libbey	13C 3419 8228	10,120	7/1/99 to 6/30/00	5	Weed control in strawberries
	NARF				
Miller & Libbey	13K 3419 5228	10,870	7/1/99 to 6/30/00	15	Weed control in green peas
Miller & Libbey	13K 3419 6228	7,050	7/1/99 to 6/30/00	10	Weed control in cucumbers
Miller & Libbey	13K 3419 7228	10,450	7/1/99 to 6/30/00	10	Weed control in vegetable seed
None (10/15/99)	Pending:				

Project No: New

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

Year Initiated 1999 Current Year 1999 Terminating Year 2001

Personnel: Lynell K. Tanigoshi, Associate Entomologist, Washington State University, Vancouver Research & Extension Unit

Chue Chen, Research Associate, Washington State University, Vancouver Research & Extension Unit

Justification:

Clay colored weevil, *Otiorhynchus singularis,* can be a serious pest of red raspberry. The weevil is a key pest in British Columbia and recently shown to be a more requent problem in Whatcom and Skagit counties. 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, cause 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 last season. 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-methy on cane fruits. This, in part, due to recent activity by the Food Quality Protection Act to achieve their mandated goals.

Objectives:

- Evaluate weevilcides which could be used to effectively control adult clay colored weevils in the future.
- Determine impact of clay colored weevil bud damage on red raspberry yield components and associations with cold damage and spur blight.

Procedures

- 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 psi and 3 mph to deliver 92 gpa.

- 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 keep it reasonable free of weevils while the other two treatments will allow weevil feeding for three and six weeks before being treated 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 to weevil damage, spur blight and cold damage. Primary and secondary lateral numbers per cane, flowers and fruits per lateral were 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 2000-2001

01	Temporary employees	$3,000
03	Supplies (field supplies, analyses	500
04	Travel (to site)	1,000
07	Benefits (16%)	480
		$4,980

We would like this grant to be submitted to the Washington State Commission on Pesticide Registration for a commensurate match. Also donations of land and crop by cooperators will be used as a part of the match.

Project No.: New

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

Year Initiated: 2000
Current Year: 2000
Terminating Year: 2002

Personnel: Lynell K. Tanigoshi, Associate Entomologist, WSU Vancouver REU, **Jeanette R. Bergen**, Agricultural Research Technologist II, WSU Vancouver REU.

Justification: Root weevil complex on red raspberry continues to be identified as a critical/priority research issue for 2000-01. Industry tolerance for root weevils is very low and both the larval and adult stages can be damaging. 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. Researchers have verified degree-day accumulations for black vine weevil emergence and egg laying potential. These parameters have verified appropriate benefits from the traditional IPM practice of applying a pre-harvest "cleanup" spray for machine-harvested red raspberries which usually occurs from late June to early July. However, regional research and understanding about aspects of life history/control literature on seasonal occurrence, reproductive potential, population dynamics and insecticide efficacy for the "other" species (i.e., strawberry root, rough strawberry root, obscure, and woods weevils) is less clear compared with the black vine weevil. Furthmore, empirical field observations suggest that controls and biological understanding of the black vine weevil does not necessary translate across to these other species. USEPA's Food Quality Protection Act has put continued registration of all neurotoxins such as OPs, carbamates and even pyrethroids at great risk. However, FQPA's potential changes for chemical registrations have created a strong reason to intensify our efforts to evaluate new chemistries, particularily the reduced risk materials for which EPA has expedited registration guidelines. Preliminary trials indicate promise for root weevil resistance with several WSU red raspberry breeding selections and *Rubus* spp. germplasm obtained from the USDA Small Fruits Breeding Program.

Objectives:

- Initiate lab life history studies (ovipositional rates, fecundity, longevity) to characterize the biology of the strawberry root, rough strawberry root, obscure and woods weevils.
- Conduct lab log concentration-probit insecticide bioassays with the strawberry root and rough strawberry weevils to registered and experimental weevilcides.
- Continue resistance screening for black vine weevil resistance with feeding and egg laying bioassays.

Procedures:

- Both overwinter adults and teneral (soft bodied, new) adult strawberry root and rough strawberry root weevils will be individually placed in Petri dishes provisioned with a bouquet of 'Willamette' leaftlet placed in a vial with water and a cotton stopper and changed as needed. The number of eggs layed between observations, generally 3-4 per week will be recorded for each female. This parameter will be monitored until the female dies or overwinters. Thus we can obtain information on weevil longevity, eggs/day, and total eggs layed in her life time or fecundity. These data sets will be conducted under controlled climate room temperatures of about 65 °F and variable photoperiods similar to seasonal changes.
- Laboratory maintained colonies of various root weevil species collected in the field will be held in a controlled climate room held at about 65 °F and fed continuously with 'Willamette' foliage. Mature females will be sprayed with various concentrations of an insecticide with the aid of a precision Potter Tower. Four to five concentrations will be plotted on a logarithmic-probability graph to determine the LC_{50} or concentration that will kill 50% of the test weevils.
- Short term feeding periods and repeated over three to four intervals during the season will test cohorts of maturing black vine weevils to several red raspberrry breeding selections and *Rubus* spp.. The surface area eaten will be measured with a Delta-T area meter and eggs oviposited/female recorded.

Anticipated Benefits and Information Transfer:

Expanding our knowledge about the basic biology of the root weevil complex in Washington State will provide growers and decision makers with species specific parameters. This understanding will help them make better timed chemical applications 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. 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:

		2000
01	Temporary employee	$4,000
07	Employee benefits (16% of 01)	640
Total		**$4,640**

PROJECT NO: **New**

YEAR INITIATED: 2000 CURRENT YEAR: 2000 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 Coop. Extension
J. Scott Cameron, Director & Assistant Dean, WSU Vancouver REU

JUSTIFICATION:

The partnership. The formation of a Lynden "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 through Fall by a project manager and assistants who worked with cooperating growers in their fields 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 the onsite staffing for important short and long term projects. As before WSU will contribute equipment (vehicles, computers, lab equipment, etc.), graduate students, and the time of state funded scientists (Tanigoshi, Cameron, Bristow, Klauer, Moore and Chen). Industry will housed our personnel and provided 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 clay-colored weevil damage assessment in the field and impacts of split trellis and nitrogen levels on spider mite population dynamics.
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.
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.

BACKGROUND:

Entomology. Feeding by adult clay-colored weevils for three and six week periods in 1999 resulted in 20% and 32% destruction of fruiting lateral buds, respectively. Feeding damage reduced the number of fruiting laterals per cane compared with the control, but there was no significant difference between the two feeding periods. However, there was a significant reduction in average fruiting lateral length and lateral length per cane with the longer feeding period. The damage from this population density exceeded the plant's ability to compensate. Fruit weight and number of berries per cane were both significantly lower in the clay colored weevil infested plots. Finally, three and six week feeding periods reduced yield per cane by 20% and 38% respectively and reduced the estimated yield per acre by 1 ton, which represents a 25% yield reduction. Since the first reported feeding and colonization of the yellow spider mite on red raspberry in Whatcom and Skagit counties. Yellow spider mite population levels often exceed those of the twospotted spider mite. Yellow spider mites are now

widespread in Clark and Cowlitz counties along with the McDaniel spider mite in Clark County. The European red mite is also present in Whatcom and Skagit counties and if not controlled can peak at over 30 motile stages per leaflet in late August. Numerous researchers have shown that spider mite fecundity appears to be associated with nitrogen fertilization, seasonal nitrogen levels, temperature and light. Most of the literature research has been reported for European red mite and the twospotted spider mite. Field observations suggest that plant architecture (i.e., single vs. split trellis) and the trend toward enhanced rates of nitrogen may be factors that have affected the dramatic incidence of new spider mite species commonly colonizing red raspberry.

Horticulture. Work with the split trellis over the last four years has shown that this cane training system increases light penetration into the raspberry canopy and results in a large increase in canopy growth, fruit and lateral number/cane. Estimated yield potential has consistently been 20-60% greater for the split trellis, but harvesting this fruit with current machine harvesters has been somewhat problematic. Actual machine pick yields were closer to 10-13% greater for the split trellis two seasons ago. This year we minimized problems with lateral damage and removal of green fruit by making two simple adjustments to the Littau harvester suggested by factory engineers. This resulted in an actual yield increase of almost 20% for the split trellis in our Lynden trial. Yield increases of this magnitude generally become economically favorable when compared to the cost of installing and maintaining a split trellis. There is a strong possibility of achieving even greater yields by experimenting further with the timing and fine-tuning of machine adjustments. It would also be useful to determine a more precise minimum split width where increased yields offset costs favorably. Also, this system may create a different microclimate than the single wire system, the effects of which need further study in terms of cane/fruit diseases and insect/mite dynamics.

Groundwater contamination is an increasing concern throughout the country and cases of contamination with nitrates and most recently with pesticides have been found in Whatcom County. Commercial agricultural practices, as well as homeowner practices, are being more closely scrutinized. Considering this, it is increasingly important to evaluate fertilization practices within the raspberry industry. 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. Growers often apply up to 300 lbs. or more N/acre, which may be excessive.

Amounts applied will vary greatly depending upon soil type and rainfall. Pacific Northwest Extension Bulletin 176 recommends granular rates of 40-100 lbs. 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.

Breeding. Grower trials of advanced selections from the breeding program provide valuable feedback on the performance of those selections and influence which ones are carried forward and eventually released as new varieties. Horticultural characteristics and yield data are obtained from replicated plantings at WSU sites in Mt. Vernon, Puyallup and Vancouver, but these plantings are not harvested by machine. Information on how well advanced selections machine harvest is critical and can be obtained from grower trials.

Plant Pathology. 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. The trial was 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.

Cultural practices modify the microclimate within the canopy, which can influence disease pressure. Does the split trellis alter the plant canopy enough to reduce pressure from disease such as gray mold fruit rot and spur blight? Until newer fungicides are approved to control gray mold fruit rot, continued testing of new materials is necessary.

PROCEDURES:

Entomology. 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 keep it reasonable free of weevils while the other two treatments will allow weevil feeding for three and six weeks before being treated 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 to weevil damage, spur blight and cold damage. Primary and secondary lateral numbers per cane, flowers and fruits per lateral were counted and lateral length measured. Photosynthetic and fluorescence parameters will be measured on five leaves per plot during the late fruit season. Fruiting canes per plot will be counted and fruit weighed five times during harvest. Pending labor and logistical demands during the harvest season, we will refine yield component estimates from machine harvest data. Spider mite population densities will be assessed from 25-20 fruiting cane and later primocane foliage per plot with a mite brushing machine. Plant parameters such a nutritional analyses, light, temperature and leaf physiology will be measured concurrently with those used by horticulture and plant pathology.

Horticulture. During 2000, a trellis site will be established in a vigorous field in Northern WA with a grower possessing an over-the-row Littau harvester. Actual yield, canopy growth, damage assessment and various physiological data will be assessed. A cost/benefit analysis will be performed. Timing and degree of machine harvester adjustments will be experimented with. Work will be integrated with plant pathology and entomology research.

During 2000, a site for a fertilization trial will be established in Whatcom County. During Spring, replicated plots will be treated with different rates of granular fertilizer ranging from the current very low-end (40 lbs/acre) WSU recommended rate to the higher rates currently being used by some growers. 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 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 will be followed over 3 years in order to fully evaluate the treatments. There may be 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 under ripe fruit. Plants will be examined for missed ripe fruit and lateral damage. The ground will examined for dropped fruit.

Plant Pathology. During 2000, two test sites will be established on commercial farms where root rot is a problem (one in Skagit Co. and one in Whatcom Co.) to evaluate raised beds and gypsum 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 year to document plant survival and productivity.

Fruit and cane diseases will be monitored in trellis design and nutrition trials. In 1997 and 1998 the most vigorous fields appeared to have the highest incidence of gray mold fruit rot. In 1999, however, adding nutrients to fungicides applied during bloom and the berry development stages did not increase fruit rot.

A fungicide trial will be conducted in a commercial field to continue the evaluation newer fungicides for control of gray mold fruit rot. Fungicide timing will be looked at with the goal of reducing the total amount of fungicides needed to control fruit diseases.

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 regional and national grower's meetings as well as through local, regional, and national publications. Newsletters and other extension and industry publications will be used to update industry on new developments as appropriate.

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 heart of the red raspberry industry in northern Washington.

BUDGET:

	2000 Request
01 Wages (Temporary employees)	$12,480
03 Supplies and services (field supplies, analyses)	3,200
04 Travel (to sites)	2,600
05 Equipment	500
07 Benefits (16% of 01)	1,997
TOTAL	$19,777
AMOUNT REQUESTED FROM WRRC FOR 2000	**$9,777**

The balance of the total will be requested from the Northwest Agricultural Research Foundation.

IN-KIND SUPPORT FROM INDUSTRY:
Office space, living quarters, 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 scientists' time.

OTHER SUPPORT OF PROJECT:
None at present; attempts to be made for additional personnel funding.

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