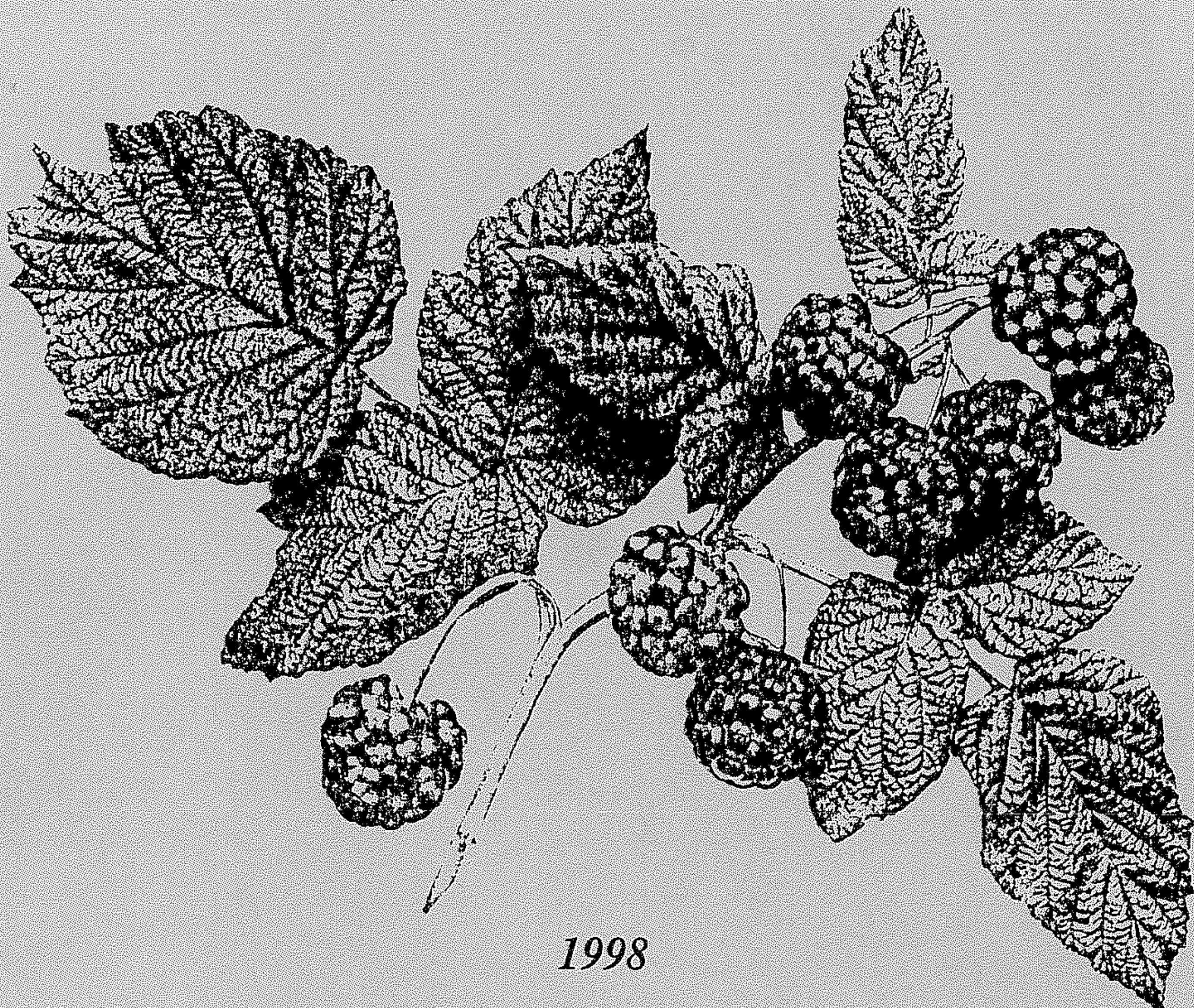


1998

RED RASPBERRY RESEARCH PROPOSALS

1997 PROGRESS REPORTS

to the

WASHINGTON STATE RED RASPBERRY COMMISSION

and

NORTHWEST RED RASPBERRY GROWERS ASSOCIATION

WASHINGTON RED RASPBERRY COMMISSION
1997-98

Randy Honcoop
9696 Northwood Rd.
Lynden, WA 98264
360/354-1155

Terry Carkner, VP-Treasurer
4520 River Road East
Tacoma, WA 98443
206/922-1604

Rolf Haugen
507 Brookfield Ct.
Lynden, WA 98264
360/354-4764

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

Frank DeVries
752 Loomis Trail Road
Lynden, WA 98264
360/354-1134

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

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

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

Anne Seeger, Administrator
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

Dave Youngquist
1427 Kamb Rd.
Mt. Vernon, WA 98273
360/424-1208

Monte Maberry
816 Loomis Trail Road
Lynden, WA 98264
360/354-1293
360/354-2094 office

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.97/cm
9/97

TABLE OF CONTENTS

On-Going Projects

On-Going Projects (Continued)

On-Going Projects (Continued)

NEW PROJECTS

Summary
Budget Requests

On-Going Projects

Project No.	Short Title	Lead Scientist	Amount Requested
13C-3755-5641	Raspberry Breeding	Moore	$ 30,000
13C-3755-7641	Advanced Testing/Vancouver	Moore	6,750
13C-3755-8641	Advanced Testing/Mt. Vernon	Moore	6,750
13C-3543-5967	Northern Washington Research	Tanigoshi	31,700
13C-3543-6967	Twospotted Spider Mite Resist.	Tanigoshi	6,300
13C-3555-2783	Advance Testing-Caneburning	Cameron	13,000
13C-3555-5784	Yield Efficiency	Cameron	10,500
13C-3761-7784	Resistance to Root Rot	Bristow	3,220
13C-3761-6718	Control of Phytophthora	Bristow	3,560
--- ---- ----	Resistance to Root Weevils	Vrain	6,500
13C-3761-3785	Yellow Rust Fungus	Bristow	3,430
13C-3761-3784	Didymella Applanata	Bristow	5,045

New Projects

Short Title	Lead Scientist	Amount Requested
Orange Tortrix Control	Tanigoshi	$ 2,320
Heritability & Sensory Impact	Fellman	5,200
Cultivar Development for PNW	Kempler	8,000
Transmission of RBDV	Martin	4,000
Tomato Ringspot Virus	Martin	8,000
Bushy Dwarf Resistance	Martin	10,000
Nitrogen use in 'Meeker'	Strik	4,875
Caneburning in Red Raspberries	Miller	7,000

A:Raspbk.98/cm 11/97

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: 1997

Accomplishments: In 1997, 60 crosses were made for cultivar development. Thirteen additional crosses were made between 'Meeker' and 'Tulameen' and 9 *Rubus* spp. About 4,400 seedlings were planted at Puyallup from 1996 crosses. Selections will be made among these seedlings in 1999 and 2000. A new replicated planting was established with forty-eight clones on raised beds. Seventy-one selections were made from seedlings planted in 1994 and 1995, 64 for cultivar development and 7 for breeding purposes. Glen Ample, WSU 968, Tulameen and WSU 1024 were the best parents. Ten selections were made among seedlings planted at WSU Vancouver REU. Twenty-six of the selections made at WSU Puyallup have the possibility of being RBDV resistant.

The 1994 replicated planting was harvested for the second time in 1997 (Table 1). Meeker was the highest yielding in 1997 and had the highest two-year total yield. WSU 1024, WSU 1035 and WSU 1112 had the next highest two-year total yields. WSU 1112 had very large and firm fruit. WSU 1024 is being tested by growers and WSU 1035 and WSU 1112 are being propagated for testing. Both WSU 1035 and WSU 1112 may have RBDV resistance.

The 1995 replicated planting was planted in an area with high levels of root rot, which resulted in missing plots and high variability (Table 2). Meeker had the highest yield. Selections WSU 1142, WSU 1132, WSU 1140, WSU 1139, and WSU 1136 had the next highest yields, however all of these had one plot die from root rot. WSU 1145 appeared very vigorous and productive despite being surrounded by root rot.

Ten selections (WSU 1024, WSU 1066, WSU 1067, WSU 1068, WSU 1082, WSU 1090, WSU 1096, WSU 1097, WSU 1098, and WSU 1099) are being tested under commercial growing conditions. Seven growers received a total of 1,400 plants for trial. Six of the selections have a parent that is RBDV resistant, and may inherit RBDV resistance. WSU 1024 thought to be possibly RBDV resistant, but when planted in a field with many infected plants, became infected.

Publications:

Moore, P.P. Year-to-Year Consistency of Harvest Data in Raspberry Breeding Plots. J. Amer. Soc. Hort. Sci. 122:211-214.

Moore, P.P. Estimation of Anthocyanin Concentration from Color Measurements of Raspberry Fruit. HortScience 32:135.

Moore, P.P. 1997. New Berry Cultivars for the Pacific Northwest. Proc. 1997 West. Wash. Hort Assoc. 133-135.

Moore, P.P. 1997. New Berry Cultivars for the Pacific Northwest. Proc. 1997 Oregon Hort. Soc. Proc. 89:173-175.

Presentations:

January, 1997. Strawberry and Raspberry fruit display. Northwest Food Processors, Portland, OR.

January, 1997. Raspberry Fruit Display. Oregon Raspberry and Blackberry Commission, Aurora, OR.

July, 1997. Raspberry Field Day, Puyallup, WA.

July 1997. Small Fruit Open House, Mt. Vernon, WA.

Table 1. 1996-97 harvest of 1994 planted raspberries, Puyallup, WA.

Clone	RBDV	Yield 1996 (t/a)	Yield 1997 (t/a)	Yield Total (t/a)	Fruit Weight (g)	Fruit Firmness (g)	Fruit Rot (%)	Harvest season 5% harvest	Harvest season 50% harvest	Harvest season 95% harvest	Length of Season (days)
MEEKER	S	8.4 A B	8.6 A	17.1 A	3.9 D - G	109 F G	3.3% D - G	6/24 B	7/8 A B	7/18 A B	24 C
WSU 1024	S	9.3 A	6.4 A - E	15.7 A B	4.5 C - E	141 B - D	5.6% C - F	6/24 B	7/5 B - D	7/18 A - C	24 C D
WSU 1035	PR	8.2 A - C	6.9 A - C	15.1 A - C	4.8 C D	130 C - E	7.1% B C	6/18 E	6/25 G H	7/10 D - F	22 C D
WSU 1112	PR	7.2 A - F	6.0 B - E	13.2 B - D	6.7 A	210 A	5.0% C - G	6/25 B	7/6 B C	7/17 A - C	22 C D
MALAHAT	S	7.6 A - E	5.3 B - G	13.0 B - D	4.6 C - E	141 B - D	4.2% C - G	6/17 E	6/27 G H	7/12 C - E	25 B C
WSU 1116	PR	5.9 B - F	6.9 A - D	12.7 B - E	3.5 F G	68 H	6.3% C D	6/23 B C	7/7 A - C	7/18 A B	25 C
WSU 1110	PR	5.5 C - F	7.1 A B	12.6 B - E	3.8 E - G	100 G	4.1% C - G	6/20 C - E	7/6 B C	7/20 A	30 A B
WSU 1107	S	7.3 A - F	4.9 B - H	12.2 C - E	3.9 D - G	141 B - D	1.9% G	6/20 C - E	7/7 A - C	7/21 A	31 A
WSU 1109	S	5.5 C - F	6.5 A - E	12.0 C - E	4.3 C - F	121 E F	1.8% G	6/15 E	6/21 I	7/6 F G	20 C D
WILLAMETTE	R	6.6 B - F	4.9 B - H	11.5 D E	4.4 C - E	123 D - F	2.0% G	6/17 E	6/23 H I	7/9 D - F	22 C D
COMOX	S	7.8 A - D	3.3 F - H	11.1 D - F	4.0 D - G	143 B C	3.4% D - G	6/17 E	6/24 G - I	7/8 E F	21 C D
CHILLIWACK	S	6.2 B - F	4.8 B - H	11.0 D - F	3.8 E - G	127 C - E	3.1% D - G	6/19 C - E	6/28 F G	7/12 C - E	23 C D
WSU 1105	S	6.7 A - F	4.2 E - H	10.9 D - F	5.7 B	143 B - D	9.4% B	6/25 B	7/5 B - D	7/14 B - D	19 C D
WSU 1113	S	5.3 D - F	5.6 B - F	10.9 D - F	4.7 C D	132 C - E	9.9% B	6/15 E	6/21 I	7/3 G	18 D
TULAMEEN	S	5.6 C - F	4.3 D - H	9.9 D - F	4.5 C - E	134 C - E	5.5% C - F	6/20 C - E	6/26 G H	7/12 D E	22 C D
WSU 1115	S	4.8 F	4.9 B - H	9.7 D - F	4.2 C - F	142 B - D	4.4% C - G	6/20 C - E	7/2 D - F	7/13 B - E	23 C D
BC 85-18-16**	?	4.6	4.9	9.5	3.1	106	3.1%	6/27	7/9	7/23	26
WSU 1108	S	5.1 D - F	4.3 E - H	9.4 E F	4.0 D - G	141 B - D	2.5% E - G	6/19 C - E	7/1 E F	7/13 B - E	24 C
WSU 1114	S	4.8 F	4.4 C - H	9.3 E F	4.3 C - F	159 B	2.4% E - G	6/23 B - D	7/3 C - E	7/12 C - E	19 C D
BC 86-5-16	?	5.0 E F	2.9 G H	7.9 F	3.3 G	137 C - E	3.1% D - G	6/17	6/25	7/11	24
WSU 1030	?	-	5.3 B - G	-	5.1 B C	130 C - E	5.7% C - E	6/19 D E	6/27 G H	7/10 D - F	21 C D
WSU 1111	S	-	5.1 B - H	-	4.2 D - F	142 B - D	2.2% F G	6/18 E	6/24 G - I	7/10 D - F	22 C D
WSU 1104	S	-	2.8 H	-	5.6 B	157 B	14.6% A	7/1 A	7/11 A	7/21 A	20 C D
WSU 1106	S	-	1.2	-	4.5	153	2.0%	6/27	7/5	7/12	15
Average		6.4	5.4	11.7	4.3	132	4.4%	6/20	6/30	7/13	23

RBDV: S = known susceptible; R = known resistant; PR = possible resistant; ? = unknown

Values are means of three plots of three plants each. Means within a column followed by the same letter are not significantly different using Duncan's Multiple Range Test, P = 0.05

Clones identified by ** were represented by only two plots.

Table 2. 1997 harvest of 1995 planted raspberries, Puyallup, WA.

Clone	RBDV	Yield (t/a)	Fruit Weight (g)	Fruit Firmness (g)	Fruit Rot (%)	Harvest season: 5% harvest	50% harvest	95% harvest	Length of Season (days)
Meeker	S	9.3 A	3.9 B - D	115 D - F	4.0% C D	6/25 B	7/4 B C	7/16 A - C	21 B - D
WSU 1142**	PR	8.8	4.6	108	11.5%	7/1	7/9	7/24	24
WSU 1132**	S	7.6	4.6	176	6.5%	6/26	7/7	7/23	27
WSU 1140**	PR	7.0	4.0	112	7.2%	6/22	7/2	7/16	24
WSU 1139**	PR	6.6	4.5	108	6.6%	6/20	6/29	7/13	24
WSU 1136**	PR	6.5	2.8	95	3.9%	6/24	7/3	7/16	22
WSU 1145	PR	6.4 A	4.5 A B	133 C	17.6% A	6/30 A	7/11 A	7/20 A B	20 C D
WSU 1121	S	6.2 A	4.2 A - C	173 A	6.5% C	6/16 C D	6/29 C D	7/12 C - E	25 A - C
WSU 1066**	PR	6.1	4.9	136	9.7%	6/16	6/25	7/11	25
WSU 1128	S	6.1 A	3.6 D E	106 F	6.1% C D	6/14 D	6/27 C D	7/10 C - E	26 A B
Tulameen	S	6.1 A	4.5 A	143 B	4.3% C D	6/23 B	6/30 B - D	7/14 B - D	21 B - D
WSU 1068	PR	5.7 A	4.1 A - D	109 E F	7.0% C	6/14 D	6/21 E	7/7 E	22 A - D
WSU 1122	S	5.7 A	2.7 G	139 B C	5.5% C D	6/17 C D	6/29 C D	7/12 C - E	25 A - C
WSU 1067	PR	5.6 A	4.2 A B C	114 E F	11.3% B	6/25 B	7/6 A B	7/19 A B	24 A - C
WSU 1137	PR	5.4 A	3.8 C D	175 A	3.9% C D	6/23 B	7/5 A B	7/21 A	27 A
WSU 1141**	PR	5.1	3.9	128	13.0%	6/21	7/3	7/17	26
WSU 1134	PR	5.1 A	3.3 E F	124 D	2.8% D	6/18 C D	6/28 C D	7/13 C - E	25 A - C
WSU 1135**	PR	5.1	3.4	111	3.5%	6/24	7/5	7/18	24
WSU 1133	PR	5.0 A	3.9 B - D	118 D E	4.2% C D	6/19 C	6/26 D E	7/9 D E	20 C D
WSU 1127**	PR	4.9	4.9	134	8.1%	6/18	6/25	7/5	17
WSU 1138	PR	4.9 A	3.0 F G	82 G	4.3% C D	6/19 C	6/28 C D	7/7 E	18 D
Willamette**	PR	4.3	3.7	123	4.5%	6/19	6/25	7/9	20
JAM-1*	?	3.5	3.4	110	7.8%	6/10	6/21	7/7	27
WSU 1125**	PR	3.3	3.7	107	11.8%	6/14	6/21	7/1	18
Average		5.9	3.9	124	7.1%	6/20	6/30	7/13	23

RBDV: S = known susceptible; R = known resistant; PR = possible resistant; ? = unknown
Values are means of three plots of three plants each. Means within a column followed by the same letter are not significantly different using Duncan's Multiple Range Test, P = 0.05. Clones identified by ** were represented by only two plots and those identified by * were represented by only one plot.

PROJECT: 13C-3755-5641

TITLE: Red Raspberry Breeding, Genetics and Clone Evaluation

YEAR INITIATED:1994
CURRENT YEAR:1998
TERMINATING YEAR:1998

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 which 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 aphids. 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. Sixty crosses were made for cultivar development in 1997. Crosses were also made with *Rubus* spp. 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 2000 and 2001.

3. Selections will be made among the seedlings planted in 1995 and 1996. Seedlings will be subjectively evaluated for yield, flavor, appearance, color, harvest season and growth form. For promising seedlings, fruit size, color, and firmness will be measured. 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 1997 (64 selections) will be propagated for testing in three replications of three hill plots and compared to standard cultivars. Seven other selections made in 1997 will be used for breeding only. Selections will be evaluated for yield, fruit size, fruit firmness, fruit rot, and harvest season as well as pest and disease resistance in 2000 and 2001. A fourth replication will be planted to permit possible machine harvesting. No quantitative data will be collected from this replication.

5. The replicated planting established in 1995 will be harvested for the second time and the planting established in 1996 will be harvested for the first time in 1998.

6. Because of risk of root rot from field propagated plants, shoots of promising selections will be collected and placed into tissue culture. Plants will be multiplied in tissue culture and propagated for testing at other locations and grower trials. Selections that are currently being propagated that may be available for grower trial in 1998 are WSU 1035, WSU 1080, WSU 1112, and WSU 1145. A limited number of plants of WSU 1068, WSU 1082, WSU 1090, and WSU 1097 were distributed in 1997, additional plants are being propagated for possible distribution in 1998.

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

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

New raspberry cultivars that 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. 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 1997-98 by other commissions. 0.2 FTE for a graduate student assistantship is being requested to assist the Agr. Res. Tech I. The remaining funds in the request will be used for timeslip labor for harvest, data collection, greenhouse supplies and travel to research plots and to grower meetings to present results of research.

Budget:	**1997-98**	**1998-99**
00 Salaries		
Agr. Res. Tech. 0.25 FTE	$7,076	$7,690
G.R.A. I 0.20 FTE	3,873	4,116
01 Timeslip Labor	7,000	7,000
03 Service and Supplies	4,114	4,166
04 Travel	500	500
07 Benefits		
Agr. Res. Tech.	2,760	2,922
G.R.A. I	2,557	2,486
Timeslip	1,120	1,120
Total	**$29,000**	**$30,000**

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.	$6,000	1997-98		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
J. Scott Cameron, Associate Horticulturist, WSU Vancouver

Reporting Period: 1997

Accomplishments:
In 1996, the planting established in 1994 was harvested for the first time. Because of the high levels of root rot, harvest data was not collected at WSU Vancouver in 1997. The plots were maintained for observation purposes. All clones suffered root rot damage. Some plots of WSU 1024 and WSU 1035 were vigorous and productive, others were weaker.

A new planting of 17 clones was established at WSU Vancouver in 1996. In addition to standard cultivars the planting included NY-7 a new cultivar from the breeding program at Cornell, ORUS 2078, ORUS 958-10, BC 86-6-15 and WSU selections 1024, 1067, 1068, 1082, 1096, 1097, 1098 and 1099. This planting will be harvested in 1998 and 1999.

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: 1998
TERMINATING YEAR: 1998

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 new 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 1998 and 1999.

2. A new replicated planting of raspberry clones will be established at WSU Vancouver 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 Vancouver. This planting will need to be maintained and the plants trained. It will be harvested for yield in 2000 and 2001.

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:	**1997-98**	**1998-99**
01 Timeslip Labor	1,250	4,500
03 Service and Supplies	550	1,380
04 Travel	150	150
07 Benefits	200	720
Total	**$2,150**	**$6,750**

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: 1997

Accomplishments:
In 1997, the planting established in 1994 was harvested for the second time (Table 1). WSU 1024 had the highest yield in 1997 and the highest two-year total. Although WSU 1035 had lower yields than WSU 1024, the yields of WSU 1035 did not differ statistically from Meeker. In previous tests of WSU 1035, it has had consistent good yields, but no exceptional yields. One of the parents of WSU 1035 is RBDV resistant and WSU 1035 may be RBDV resistant.

A new planting of 18 clones was established at WSU Mt. Vernon in 1996. In addition to standard cultivars, the planting included NY-7 a new cultivar from the breeding program at Cornell, ORUS 2078, ORUS 958-10, BC 86-6-15 and WSU selections 1024, 1066, 1067, 1068, 1082, 1096, 1097, 1098 and 1099. This planting will be harvested in 1998 and 1999.

Presentations:

July 1997. Small Fruit Open House, Mt. Vernon, WA.

Table 1. 1996-97 harvest of 1994 planted raspberries, Mt. Vernon, WA.

Clone	Yield (t/a) 1997	Yield (t/a) 1996	Yield (t/a) Total	Fruit weight (g)	Fruit Rot (%)	Harvest season: 5% harvest	Harvest season: 50% harvest	Harvest season: 95% harvest	Harvest season: Length of season (days)
WSU 1024	15.7 A	14.8 A B	30.5 A	4.1 A	1.8% B	6/26 A	7/7 A	7/20 A	25 A
Comox	12.0 B	16.1 A	28.0 A B	3.9 A	3.2% A B	6/26 A	7/5 B	7/20 A	24 A
Meeker	13.9 A B	11.6 A B	25.6 B C	3.4 B	2.3% B	6/26 A	7/7 A	7/20 A	24 A
MALAHAT	12.7 B	12.6 A B	25.3 B C	3.9 A	2.9% A B	6/19 C	6/27 D	7/14 C	24 A
WSU 1035	11.3 B	10.4 B	21.7 C	3.9 A	4.6% A	6/23 B	7/2 C	7/17 B	24 A
Average	13.1	13.1	26.2	3.9	3.0%	6/24	7/3	7/18	24

Values are means of three plots of three plants each. Means within a column followed by the same letter are not significantly different using Duncan's Multiple Range Test, P = 0.05.

PROJECT NO.: 13C-3755-8641

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

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

YEAR INITIATED: 1996
CURRENT YEAR: 1998
TERMINATING YEAR: 1998

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 18 raspberry clones was established at WSU Mt. Vernon in 1996. This planting will need to be maintained and the plants trained. It will be harvested for yield in 1998 and 1999.

2. A new replicated planting of raspberry clones will be 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. This planting will need to be maintained and the plants trained. It will be harvested for yield in 2000 and 2001.

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 maintenance and harvest of raspberry plots at WSU Mt. Vernon. This will include obtaining posts, wire, and herbicides. Travel would be to local grower meetings and to research plots.

Budget:	**1997-98**	**1998-99**
00 Salaries		
Agr. Res. Tech 0.125 FTE	$3,347	
Agr. Res. Tech 0.10 FTE		$2,785
01 Timeslip Labor	2,000	2,000
03 Service and Supplies	578	576
04 Travel	150	150
07 Benefits		
Agr. Res. Tech.	1,105	919
Timeslip	320	320
Total	**(request) $7,500 ($5,000 funded)**	**$6,750**

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	$5,776	1998-99		Evaluation of small fruits at WSU Mount Vernon

PROJECT NO.: 13C-3543-5967

TITLE: A NEW MODEL FOR COOPERATIVE, INTEGRATED ENTOMOLOGICAL AND HORTICULTURAL RESEARCH IN NORTHERN WASHINGTON

PERSONNEL: *Co-Principal Investigators*

Lynell K. Tanigoshi — Associate Entomologist
J. Scott Cameron — Superintendent and Assistant Dean
Washington State University Research & Extension Unit, Vancouver

COOPERATORS:
Chuhe Chen, Stephen F. Klauer, Research Associates, WSU Vancouver
Craig MacConnell, Whatcom County WSU Coop. Extension
Arthur L. Antonelli, WSU State Extension Specialist, Entomology, Puyallup
Geoff Menzies, Nooksack Watershed IPM Project
Malika Bounfour, Ph.D. student, Entomology

REPORTING PERIOD: 1997

ACCOMPLISHMENTS: *1997*

The innovative model for a satellite facility in northern Washington has continued to gain support from the raspberry industry and to gain new partnerships. In terms of research accomplishments, the project made very significant progress in both entomology and horticulture. With regard to education and outreach, a number of successful extension education events were held at the satellite facility this year and a strong partnership with the Nooksack IPM project created additional synergy. This model proved flexible and cost effective in bringing together federal, state, and industry resources as base funding from industry was used to leverage additional funds to enhance research activites in the northern and southern arenas across the entire industry.

GENERAL ACCOMPLISHMENTS FOR THE YEAR:

- ☑ Satellite research model was further evolved in partnership with industry.
- ☑ Chemical control of root weevil was studied with promising results.
- ☑ Yellow and twospotted spider mite population dynamics were studied.
- ☑ Winter injury research profiled perennially-damaged plants in susceptible sites.
- ☑ Cultural management research compared standard and split trellises.

RESULTS:

ENTOMOLOGY

Field study of the population dynamics of spider mites and their phytoseiid predator, *Neoseilus fallacis*, at the time of their emergence from diapause and subsequent activity periods, indicate that yellow spider mite disperses earlier to the upper parts of red raspberry fruiting canes than the twospotted spider mite. This dispersal behavior enables yellow spider mite to exploit young, terminal foliage before twospotted spider mite does.

Later in the season (June through September), these behavioral differences for colonization and migration often result in clearly discernible "TSSM fields" and "YSM fields."

Beginning with bud-break and early foliage in 1996 and 1997, economic populations of the clay-colored weevil have increasingly been reported in the northern regions of the red raspberry district in Whatcom County. Laboratory feeding data clearly showed that the weevil is an early season species whose reproductive cycle does not over lap that of the more prolific black vine weevil and it possesses a shorter egg developmental period. Lab rearing of both species through their adult period shows two distinct ovipositional periods for the black vine weevil. The first one represented egg production of females that overwintered and emerged without having to undergo the "new female" 3-5 week preovipositional period. The second period was longer and represents higher fecundity and daily egg production by new generation females that commenced ovipositing their eggs later in the postharvest period. This pattern empirically supports the management notion of controlling the new generation adults before they begin to lay their eggs in the soil. The majority of eggs laid by the overwintering adults will not be affected by the effective clean-up spray traditionally applied prior to harvest in early July.

Multiple chemical trials to compare basal applications of the experimental insecticide/miticide Alert and several registered root weevil adulticides with basal and overrow applications of the standard Brigade (Sect. 18) were conducted in both raspberry growingregions of the state. Alert was submitted to IR-4 earlier in the year and residue tolerance evaluation on red raspberry funded by American Cyanamid Company. Brigade continues to look excellent as a weevilcide at recommended rates when applied as either a basalar or overrow application. Alert performed equally as well though its knock down was delayed by about 3 days due to its mode of action as a metabolic toxin. Alert's persistence was comparable to that of Brigade. Registration of Alert will provide the industry with a biorational insecticide/miticide that will complement Brigade and perhaps reduce the potential for resistance development by arthropod pests native to the intensively managed red raspberry ecosystem.

HORTICULTURE

SPLIT TRELLIS. In its first year (1996), the split trellis at Lynden performed differently than a conventional trellis in a number of ways, increasing yield per cane by 50%. This was done through more efficient cane, lateral and leaf growth. These canes produced more fruit even though their flower buds had actually been formed under the conventional system by the Fall of 1995. Since there were no significant differences in lateral numbers or lateral length between the two systems, this response was due to increased floral expression\set of previously initiated flowers, increases from Spring floral bud initiation, or both. Cane growth was also more manageable as cane lengths were reduced 20%.

In 1997 yields in the split trellis were not signficantly increased in the second year for this original site, likely in part to the confounding effects of root rot at this site. Two other sites this year had yield increases in the split system (Lynden, Woodland. Canopy width and circumference data demonstrates the potential of crossarm width in this system as too narrow a crossarm will lose the advantages of light penetration and surface area, while too wide a canopy will experience damage during machine harvest. As perhaps a reflection of increased light penetration in the previous (establishment) year, laterals were longer, and total leaf area per cane and cane dry weights were greater in this planting. At another Lynden farm in 1997, harvested yields were greater in the split system by 33% after six harvests. The general obvservation at a number of sites appears to be that the split system brings fruit on a bit earlier, but that the increases in yield are fairly consistent across the season. Our data once again demonstrates that the split system encourages more fruit at all positions along the cane, with a larger increase at the top of the cane.

WINTER INJURY. The winter of 1996-97 did not produce the same level of winter injury as the previous winter, thus this season was a good opportunity to evaluate the process and effect of a "recovery" year. The two test sites paired perenially damaged portions of field versus controls and were in a well manged, productive field and a weaker, less productive field. In general it would appear that with a reduced crop load in perennially winter injured plots in 1996, these plants were theoretically able to devote more energy into developing the 1997 crop. This is supported by overall cane lengths and bud number per cane being higher in previously winter injured areas of both fields compared to control plots which historically do not suffer perennial winter injury.

The other side of this situation is that while it was not as severe a winter in terms of injury, the perennially damaged areas of the fields were again damaged compared to controls, even in a milder year. Damaged plots still had higher levels of cane dieback, % of cane dieback, number of dead or dormant buds per cane, and percent of dead buds in both fields, especially at site 2. Thus, even in a milder winter, sensitive areas of the fields were still damaged, with the larger canes of the "recovering" plots having more buds, but also being more of a target. While this resulted in less clarity in yield component analysis, it is an extremely important set of observations as it is of great value to understand the allocation of resources in fields attempting to recover from winter injury.

In this regard, control plots had greater average lateral length, total lateral length, and higher berry numbers per lateral, especially in laterals from primary buds at both sites. Thus, in a susceptible site, even a relatively mild winter can reduce the length and productivity of laterals. There were also differences in the balance of primary and secondary laterals expressed.

Leaves on canes in cold damaged areas had greater levels of photosyntheitc activity than did those in control plots. This may relate to both sets of plots having more similar crop loads than last year but the winter injured plants having a reduction in leaf area, thus higher demand per leaf area for photosynthates.

ACKNOWLEDGMENT: We express our appreciation to the many people in the red raspberry industry who have supported this program by allowing us to work in their fields. Special thanks to Curt Mayberry Farms for their hospitality and professional courtesy in providing facilities and site based assistance for the satellite project. This cooperative model would have never developed without the assistance and support of the industry.

PROJECT NO.: 13C-3543-5967

YEAR INITIATED: 1996 CURRENT YEAR: 1997 TERMINATING YEAR: 1998

TITLE: A NEW MODEL FOR COOPERATIVE, INTEGRATED ENTOMOLOGICAL AND HORTICULTURAL RESEARCH IN NORTHERN WASHINGTON

PERSONNEL: *CO-Principal Investigators*
Lynell K. Tanigoshi, Associate Entomologist, WSU REU Vancouver
J. Scott Cameron, Superintendent & Assistant Dean, WSU REU Vancouver
Peter P. Bristow, Associate Plant Pathologist, WSU REC Puyallup

COOPERATORS:
Chuhe Chen, Stephen Klauer, Research Associates, WSU REU Vancouver
Craig MacConnell, Chair, Whatcom County WSU Coop. Extension
Arthur L. Antonelli, Extension Entomologist, WSU REC Puyallup
Geoff Menzies, Nooksack Watershed IPM Project
Malika Bounfour, Ph.D. Student, Entomology, WSU REU Vancouver

JUSTIFICATION:
A New Partnership. In 1996 we proposed a flexible, cost effective partnership which brought federal, state, and industry resources together to cooperatively address research needs in northern Washington while enhancing the role of WSU Cooperative Extension in education and technology transfer. We established a "satellite" office of our research programs in Lynden, WA, which was staffed from Spring through Fall by a project manager and staff who used local fields for specific projects established as priorities by industry. Scientists, students and staff from Vancouver travelled routinely to Lynden to establish and monitor experiments.
Contributions. This project created a flexible approach to staffing critical short\long term projects with specific expertise, focus and dedication. WSU has contributed equipment (vehicles, computers, lab equipment), grad students, and the time of state funded scientists (Tanigoshi, Cameron, Bristow, Klauer, and Chen). Industry has housed our personnel and provided timeslip 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 types of research which we otherwise wouldn't have done without an onsite manager and a local base of operations, and this 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: ***(All objectives to be addressed in 1998)***
① Establish base of operations for locally managed, joint, interdisciplinary projects under the direction of Drs. Tanigoshi, Cameron and Bristow.
② Conduct paired plot, on-farm research designed to compare traditional pest control with "best" contemporary pest management systems (i.e., arthropod pests, plant diseases, vegetative management) as viewed in the context of whole-farming systems by an expert committee of researchers, extension specialists and growers/managers.
③ Study the roles of carbon, water, temperature and pests in sustainable productivity.
④ Enhance the role of WSU Cooperative Extension in integrated pest management education and technology transfer to the Washington red raspberry industry.

BACKGROUND:

ENTOMOLOGY. The root weevil complex of the black vine and clay colored weevil, and the twospotted spider mite, continue to be identified as the main entomological research priorities by the commission. Moreover, since the first reported feeding of the yellow spider mite on red raspberry in northwestern Washington, their population levels often exceed those of the twospotted spider mite. What factors are influencing population increase and cohabitation of these two spider mite species and need to chemically control western raspberry fruitworm? Traditional factors for consideration are pesticide induction, horticultural practices, negative impacts on natural enemies (i.e., pesticide selectivity) or phenomenon of competitive displacement. Furthmore, we reported the first finding of economic levels of McDaniel spider mite in Washington state from Clark County. This past summer found us conducting on-farm efficacy trails to identify softer insecticides to control increasing incidences of injurious levels of orange tortrix. Enhanced grower to researcher access in the northern region will expedite the forging of appropriate partnerships between the industry and Washington State University. This collective spirit has begun to accelerate mutual discoveries of sensible scientific and biological solutions to contemporary red raspberry arthropod management problems. The project has already broadened and deepened the industries understanding of traditional IPM tactics of chemical, biological and pest resistant plants and has begun to explore autocidal, cultural, physical and mechanical control strategies were deemed appropriate to obtain cost-effective, long-term, profitable and environmentally sound pest management systems.

HORTICULTURE. WSU horticulturists have developed a unique program which has greatly increased our understanding of the biology, growth and development of the red raspberry plant. This plant, while only putting a fraction of its total energy into fruit production, still acts resource-limited. There are many possible reasons for this behavior which could involve its desire for a cool shoot\warm root temperature environment, strong intraplant demand for resources, sensitivity to warm temperatures and susceptibility to fluctuating winter temperatures. The common denominators among problems and concerns surrounding these issues include yields, carbon acquisition, allocation and storage within the plant, year-round water relations, plant nutritional status, development of pest populations and their control and air\soil temperatures throughout the year. The satellite project has already given us significant new information related to the environmental and cultural factors related to winterhardiness and yield efficiency. It is time to focus these projects and more fully integrate them with issues related to pest management.

PLANT PATHOLOGY. Two primary disease issues which merit study through integration with the ongoing work of this project include yellow rust and spur blight. Last summer by applying fungicides at different times between early May through late July we identified the infection period for *Didymella applanata* the fungus causing spur blight. In 1997, spur blight was a serious foliar pathogen on leaves of fruiting canes. Most leaves sustained multiple infection starting along the veins. There was also some girdling of pedicels and on occassion laterals. Fungicides applied from mid May through early June controlled the disease. In 1997, research with yellow rust yielded very little information because disease pressure was so low. However, the roles of leaf litter at the top wire as well as the timing of liquid lime sulfur so as to reduce primary inoculum merit close investigation at a site where integrated research is being conducted and environmental parameters are monitored.

PROCEDURES:

FARM-SCALE TRIALS TO COMPARE EFFICACY AND ECONOMICS OF A STANDARD PROGRAM vs INSTITUTIONALLY DERIVED PEST MANAGEMENT TACTICS

It is the consensus of the principal investigators that the third year phase of the satellite station should emphasize applied implementation research on a farm-scale and areawide evaluation of key components of abiotic, biotic and socioeconomic impacts of certain provisional red raspberry management tactics researched over several growing seasons. This will be accomplished by integrating the efforts of entomologists, horticulturists and plant pathologists. Central to gaining grower acceptance of a more ecologically-based pest management program is to include selected growers within the decison making process on 2-3 operational farms. Implementation, adoption or integration of new knowledge and traditional agronomic practices may be enhanced by growers if theirs inputs and those of researchers were gained through a concensus making process. Comparative implementation of best management practices will naturally be mitigated within the context of real world agronomic practices, ecosystem processes and technical feasibility. We believe that the complexity of the raspberry ecosystem necessitates coordinated multidisciplinary\interdisciplinary research to develop, implement and sustain all IPM strategies into a dynamic unit deemed viable to the private sector.

We propose to conduct large-scale trials of (up to one acre each), paired field blocks which would compare the two farming systems mentioned above in 2-3 different farms in the Skagit-Whatcom County region. Detailed research and applied practices will be documented, various monitoring programs to measure abiotic and biotic factors will be implemented and detailed, and respective disciplinary tactics will be implemented in the IPM block as determined by the decision-making team using a provisional red raspberry insect & disease IPM calendar (Shanks, Bristow, Antonelli, 1995). This comprehensive project will be managed and implemented by a 0.5 FTE Associate in Research who will be located in Lynden. This person will be aided by a part time assistant and various research associates, research technicians, graduate students and other part temporary personnel associated with the respective co-PIs when appropriate for various phenological time periods for host plant, pests, natural enemies and application of agrichemicals. The respective blocks will be scaled to facilitate calculations for application machinery and yield data with a conventional field harvester. With the cooperation of each grower to provide dollar figures for inputs for the traditional block and collaborations with the grower and researchers for the institutional blocks, this multi\interdisciplinary effort will provide excellent applied research data along with social and economic outputs which will provide valid data to compare the short\long term feasbility or economic life of both strategies.

ENTOMOLOGY. Based on multiple seasons of laboratory and field trials with the insecticide-acaricides Brigade (Sect. 18) and Alert (IR-4), enhanced knowledge of black vine weevil developmental (DD model) and reproductive biology (preovipositional period, fecundity), timing, dosage and selective application of both materials when coupled to our knowledge of the population dynamics of twospotted and yellow spider mites and their natural enemies, assessment of registered and experimental acaricides, we are confident that we have the basic tools (monitoring) and knowledge that will interface with like tactics being researched for plant pathogens, weed pests and horticultural efforts to improve the red raspberry plant. Only WSDA approved agrichemicals that we selectively integrate within the provisional IPM blocks will be applied as judged necessary based on standardized monitoring applied by growers and fieldmen or alternative ones being evaluated by research.

Insecticide of choice for the traditional program since 1991 has been Brigade and to a lesser extent malathion. The main entomological purpose for these collaborative pair-trials is to selectively reduce the enormous biotic potential of root weevils by exploiting their propensity to voraciously feed on fruiting laterals for several weeks before they lay their eggs in the soil. There are no registered insecticides to control the soil inhabiting larval instars that feed on plant roots from late summer to early mid-spring. Moreover, this experimental design will allow researchers and growers to observe, monitor and document with appropriate sampling techniques: 1) impact of Brigade on spider mite and population dynamics; 2) conservation or disruption of spider mite natural enemies after applying root weevil adulticides as a basal spray compared with traditional full coverage spray(s); 3) cutworm and aphid build-up and potential for other insect contaminants after applying malathion as a clean-up spray; 4) level of honey bee safety/toxicity by applying weevilcides to the basal surfaces of fruiting canes; 5) DD degree model to predict adult weevil emergence and cessation of their preovipositional period; and 6) increased incidence of the early season occurrence of treatable populations of the clay-colored weevil and western raspberry fruitworm. The Food Quality Protection Act will facilitate and fast-track registration of several biorational insecticides and acaricides we have already been trialing in red raspberry for several seasons. These pesticides exhibit modes of action completely different from our current arsenal of OP and carbamate neurotoxins whose at-risk minor uses in cane fruits will likely be lost during tolerance reassessment by USEPA.

HORTICULTURE. Several aspects of this work will be studied within the context of the larger field model and as sepreate components. In both the standard and IPM portions of the studies, we will monitor air and soil temperature as well as humidity to correlate plant growth and pest phenological patterns. We will also do representative sampling of yield components in order to qualify the nature of differences in productivity under the two systems. Physiological evaluations of photosynthetic performance, chlorophyll content and fluorescence and dry matter allocation will be used as appropriate to address specific differences in observed plant performance due to pest dynamics or associated treatments.

Ongoing trials studying winterhardiness and split versus conventional trellising will continue in Lynden with the integration of pest scouting to better understand the overall systems being studied. Paired plots will be maintained for a third year in several locations to examine the relationships of carbon, water, nutrition, and pest phenology with temperature. With one field from the study now taken out of production, we will seek to relocate that site or sites within the new IPM study. Each location will pair sites which have historically suffered winter injury\low productivity with those which have not. Each plot will be monitored for air and soil temperatures throughout the year with new and inexpensive recording devices (HOBO) which are small, portable, and able to be left in the field for long periods of time. During the year, plot soil\air temperatures will be correlated with such factors as cane carbohydrate status, cane hydraulic conductivity (water potential), soil and leaf nutrient content, plant phenology\growth stage, physiological status (photosynthesis\chlorophyll), yield, and phenology of weevils and mites. This study will assess interactions of these factors on long term productivity and cultural\pest management practices.

Plots of conventionally trained and split trellis trained 'Meeker' will again be compared in Lynden to compare yields of the training systems. Yield estimates will be performed on canes that are monitored for carbohydrate status, nutritional status, photosynthesis, chlorophyll fluorescence, chlorophyll content and field temperature as well as mechanical harvest potential. This information will be compared with companion studies at other sites in the state.

Plant Pathology. In 1998, as part of the larger IPM on farm comparison model we will repeat the fungicide timing test to again identify the infection period for spur blight. During the same period we want to: i) operate a spore trap to catch the airborne ascospores which cause leaf infections and ii) collect cane samples to microscopically follow the development of ascocarps and the maturation of ascospores. We would operate a weather station at the test site recording rainfall, air temperature, relative humidity, windspeed, solar radiation, and leaf wetness. Close monitoring within the canopies will be done with HOBO units.

With regard to yellow rust, this variable will be incorporated into the IPM model through removal of leaf litter from between canes along the top trellis wire and through various timings of liquid lime sulfur in order to reduce primary innoculum.

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 biological controls as well as modified cultural 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. It is our intention to employ Geoff Menzies as the manager of the program so that he may continue his education and research efforts as part of our project.

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 this model as a cost effective means to draw other scientists and research programs into the heart of the industry in northern Washington. Other researchers are being encouraged to develop projects which utilize the programmatic infrastructure being developed at the satellite facility in Lynden.

BUDGET:

		1998 Request
01	Wages (Project manager for 6 months)	17,000
01	Wages (Temporary employees)	3,600
03	Supplies and services (field supplies, analyses)	3,000
04	Travel (to sites)	2,800
05	Equipment (environmental monitoring)	2,000
07	Benefits (16% of 01)	3,300
TOTAL		$31,700

Note: In 1997, this project was funded at a level of $31,836 by the WA Red Raspberry Commission ($10,000) and the Northwest Agriculture Research Foundation ($21,836).

IN-KIND INDUSTRY SUPPORT

Office space, living quarters, access to field plots, help with plot maintenance & data collection.

MATCHING WSU SUPPORT

State vehicle, 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.

Project No.: 13C-3543-6967

Title: Twospotted Spider Mite Resistance in Red Raspberry Research

Year Initiated: 1996
Current Year: 1997
Terminating Year: 1998

Personnel: Lynell K. Tanigoshi, Associate Entomologist, WSU Vancouver REU; **J. Scott Cameron,** Superintendent and Ass't Dean, WSU Vancouver, REU; **Patrick P. Moore**, Associate Horticulturist, WSU Puyallup REC; Arthur L. Antonelli, Extension Entomologist, WSU Puyallup REC

Reporting Period: 1997

Results:

Replicated Secondary Screening. Final field screening for twospotted spider mite resistance in red raspberry seedlings that had 'Brandywine', Schonemann', WSU 530, WSU 991 for parents was completed in 1997. These selections were initially evaluated for twospotted spider mite resistance in greenhouse culture for two years prior to their planting in the field in March 1995 at WSU-Vancouver REU. Eight out of sixty-two seedlings expressed one-third or less than the standard 'Willamette' on 5 August, while five seedlings retained that ranking on 19 August 1997. As was reported in 1995 and 1996, the highest percentage of plants in the one-third or less category compared were seedlings derived from 'Brandywine' x WSU 968.

Primary Field Screening of Seedlings. From the original planting of 921 plants in 1995, 848 plants were leaf brushed for twospotted spider mites levels on 5 leaves per plant for the first three counts with only 143 plants selected for the final evaluation. Of these later seedlings, 121 and 56 had one-third or fewer mite than WSU 968 and 'Meeker', respectively.

Advanced Screening/Rubus National Germplasm. Red raspberry germplasm was obtained from Drs. Chad Finn/ARS-USDA, Corvallis, OR and Pat Moore, WSU, Puyallup, WA for the National Germplasm System Study. Four red raspberry cultivars, twelve breeding selections and 34 *Rubus* spp. were evaluated in 1997. Plants were grown in an unheated greenhouse with three leaflets/plant/evaluation date evaluated for twospotted spider mite with a mite brushing machine. Five *Rubus* spp. and

'Dormanred' had one-third or fewer twospotted spider mites than 'Willamette' after the fourth count taken on 19 August.

Black vine weevil screening/Rubus National Germplasm. Using the same plants for the twospotted spider mite screenings, we conducted a black vine weevil feeding and oviposition trial. Counts began after the adult weevils had been exposed for one week on their host plant to eliminate effects of their previous feeding on other host plants. After six weeks of feeding, *Rubus pungens* (11%), *R. flosculosus* (14%), *R. innomenatus* (25%), *R. sacchalinensis* (32%), WSU 1173 (25%), WSU 1174 (32%) and 95605 (32%) averaged one-third as many black vine weevil eggs/leaf compared with 'Willamette'. The association between foliage surface eaten and ovipositional rate was unclear.

Project No.: 13C-3543-6967

Title: Twospotted Spider Mite Resistance in Red Raspberry Research

Year Initiated: 1996
Current Year: 1997
Terminating Year: 1998

Personnel: Lynell K. Tanigoshi, Associate Entomologist, WSU Vancouver REU; **Patrick P. Moore**, Associate Horticulturist, WSU Puyallup REC; Arthur L. Antonelli, Extension Entomologist, WSU Puyallup REC

Justification: The twospotted spider mite is a common problem for red raspberry producers. Feeding by this pest can damage leaves and canopies to point of defoliation. Premature defoliation leads to bud-break in the fall instead of the following spring. This also makes canes and buds more susceptible to winter injury and may alter carbon balance in the plant from year to year. Red raspberries appear to be able to tolerate some mites so that even a moderate level of resistance by the plant combined with some degree of tolerance would be of great value. While there still is a need for acaricides, this approach should greatly reduce or eliminate the need for chemical miticides. Aggressive miticide testing will continue in Tanigoshi's pesticide program.

Two clones of *Rubus, R. parvifolius* 'Cherry' and 'Dormanred' (*R. parvifolius* x 'Dorsett') were found to be very resistant to twospotted spider mites two years ago. In 1993, an advanced selection of red raspberry that was already in the field trials, WSU 968, was discovered to be as resistant as 'Dormanred.' This shows that it is very possible to develop mite-resistant red raspberry cultivars. WSU 968 and its parents are excellent starting points for a breeding program. To our knowledge, there is no other such work in the United States or elsewhere. We propose to continue screening germplasm while at the same time looking for the biological bases of these traits so that we make this process more productive and less time consuming and resource intensive.

Objectives:

1. Continue testing series of crosses using resistant WSU 968 and susceptible 'Willamette' standards and study the nature of resistance and tolerance.

2. Continue to collect and evaluate native *Rubus* clones for resistance.
3. Initiate studies in the development of a bioassay.
4. Use resistant and tolerant germplasm in a breeding program.

Procedures:

Objective 1.

Replicated Secondary Screening of Seedlings. WSU 968 was crossed with 'Cherokee', 'Sunrise', 'Meeker', 'Chilliwack', 'Glen Ample', 'Nootka', 'Tulameen', WSU 1024, WSU 1027, and WSU 994 in 1994. A total of 921 seedlings from those crosses plus 'Willamette' were planted in the field at WSU-Vancouver in 1995. They were sprayed with a pyrethroid (Asana) in 1996 and in 1997. Spider mites were counted with a mite brushing machine. The seedlings were also observed for fruit quantity and quality.

Objective 2.

Advanced Screening. All resistant *Rubus* clones from the replicated greenhouse screening in 1997 will be tested against both the twospotted spider mite and yellow spider mite because the two species may affect different clones in different ways. These include clones such as 'Dormanred', 'Cherry', WSU 968, WSU 822, WSU 1049, and St. Regis (Ranere). Native *Rubus* clones that were collected and planted in Vancouver during 1996 were screened for twospotted spider mite resistance. There are large collections of various species in the Pacific Northwest and it is this material which will be incorporated into field trials.

Objective 3.

Screening for resistance in the field and greenhouse is time consuming and labor intensive. In an effort to find ways to screen for resistance without having to directly evaluate large numbers of plants, alternative methods such as leaf disk and individual whole leaf bioassays were investigated. Further experimentation next season should identify the technique to compare against standard methods requiring mite counts on multiple, whole leaflets. In conjunction with studying the plant's response to feeding, it is also important to consider the potential effects of feeding on female twospotted spider mite (e.g., reduced fecundity, shortened life span, feeding preference). By understanding both the plant and pest response to feeding, the relative importance of resistance and tolerance in an integrated management system can be quantified.

Objective 4.

Plant material identified as resistant or tolerant will be given to the breeding program at Puyallup for controlled crosses. As the opportunity arises, Dr. Moore will, with cooperation from the Vancouver programs, seek to establish a protocol by which the nature of heritability of resistance or tolerance traits can be determined. This process could vary widely in its potential complexity.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

The programs involved in this project already have made progress in developing a pool of resistant germplasm and in beginning to understand the response of red raspberry to mite feeding. The use of mite resistant cultivars would greatly reduce the need for miticides.

Results of this research will be made available to the raspberry industry through reports to the Washington Red Raspberry Commission, at meetings and field visits with growers and through WSU Cooperative Extension publications.

BUDGET:

			1998
00	Agr. Research Tech. II		$5,000
07	Employee benefits (26% of 00)		1,300
		Total	$6,300

PROJECT NO.: 13C-3555-2783

TITLE: ADVANCED TESTING OF NEW COMPOUNDS FOR CANEBURNING OF RED RASPBERRY

PERSONNEL:

CO-PIs **J. Scott Cameron**, Superintendent & Ass't Dean, WSU REU Vancouver
Timothy W. Miller, Ass't Professor, Weed Science, WSU REU, Mt. Vernon

Chuhe Chen, **Stephen F. Klauer,** Research Associates
Carl Libbey, Research Technologist II, WSU REU, Mt. Vernon

REPORTING PERIOD: 1997

ACCOMPLISHMENTS:

- ☑ Collected data for caneburning field trials evaluating Goal (oxyfluorfen), Ignite (glufosinate) and carfentrazone for primocane suppression
- ☑ Supporting data for Section 18 for use of GOAL for caneburning in 1997
- ☑ Support for IR-4 project for glufosinate.
- ☑ Yield component analysis and primocane growth patterns quantified for various caneburning regimes.

RESULTS: Field trials for primocane suppression with GOAL (oxyfluorfen [0.2, 0.4 LB\A]) IGNITE (glufosinate [0.5, 1.0 LB\A]) and carfentrazone (0.05, 0.1 LB\A) continued in Lynden. While this study may have been partially confounded by root rot, certain trends were observed which supported previous observations. While all materials controlled canes adequately, none increased yields, suggesting that in this case, while harvest efficiency may have been gained, resource allocation to fruit did not.

Glufosinate significantly decreased yield due to decreases in berry weight, berry number per cane and cane number per acre. Carfentrazone appeared to be fairly "soft" on the plant with the least negative impact on productivity (yield) and especially on cane numbers. Oxyfluorfen appeared to be intermediate to the two other materials in terms of negative impacts on growth and productivity. Across treatments in 1997, there did not appear to be any signifcant difference in primocane diameter or height through harvest.

PROJECT NO.: 13C-3555-2783

YEAR INITIATED: 1993 CURRENT YEAR: 1997 TERMINATING YEAR: 1998

TITLE: ADVANCED TESTING OF NEW COMPOUNDS FOR CANEBURNING OF RED RASPBERRY

PERSONNEL:
CO-PIs **J. Scott Cameron**, Superintendent & Ass't Dean, WSU REU Vancouver
Timothy W. Miller, Ass't Professor, Weed Science, WSU REU, Mt. Vernon

Chuhe Chen, Stephen F. Klauer, Research Associates
Carl Libbey, Research Technologist II, WSU REU, Mt. Vernon

JUSTIFICATION: Herbicides have been widely used for years to suppress raspberry primocane growth in the spring. Caneburning was initially conducted to aid in the mechanical harvest of berries, but an enhanced level of weed control within the crop row was often 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. It is also widely suspected that this practice also leads to declines in red 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, and ideally, 4.) They should also offer some degree of weed control in the crop row, with herbicidal activity on weed species that are problematic in western Washington raspberry production.

OBJECTIVES: **(All objectives to be addressed in 1997)**

- ☑ Conduct advanced testing of primocane suppression products at various rates and in tank mixtures, evaluating them for efficacy and crop safety.
- ☑ Screen new herbicides for primocane suppression potential, weed control, and crop safety in red raspberry.
- ☑ Evaluate horticultural and physiological characteristics of plants in response to chemical primocane suppression in order to track impact on yield, primocane regrowth and long term sustainability.

PROCEDURES:

Ongoing caneburning studies will be conducted on grower raspberry fields. Products of interest are Goal (oxyfluorfen) and Enquik (monocarbamide dihydrogensulfate) , and advanced test products glufosinate and carfentrazone (several potential trade names, but none yet selected by the companies). Goal and Enquik have Washington Special Local Needs labels; glufosinate and carfentrazone have been entered into residue testing in the federal IR-4 program. All products will be applied to established raspberry plants when primocanes are 4 to 6 inches in height.

Caneburning studies with new compounds will be conducted on grower raspberry fields. New products of interest are Basagran (bentazon), Buctril (bromoxynil), Betanex (desmedipham), Spin-Aid (phenmedipham), Prefar (bensulide), and Tough (pyridate). These products meet the criteria discussed in the Justification section (i.e., they are primarily contact herbicides with little if any translocation into root systems, display short soil residuals, are not taken up by roots, and are not volatile under typical environmental conditions at the time of application). All products will be applied to established raspberry plants when primocanes are 4 to 6 inches in height.

Horticultural Evaluations. All treatments will be compared to Goal and an untreated check. Primocane suppression and subsequent regrowth (height and diameter) will be monitored periodically throughout the growing season. Observations concerning ancillary weed control will be made.

Yield estimations are accomplished by removing and analyzing four random canes per plot just before harvest. Plots are 10′ in length containing three hills trained in a modified hedgerow. During each week of harvest, plots are 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. Yield component analysis will demonstrate alterations in plant reproductive effort across treatments.

Physiological Evaluations. Where appropriate, measurements of photosynthesis, gas exchange parameters, chlorophyll and chlorophyll fluorescence will be made in order to determine stress imposed by treatments or in order to quantify impacts of altered resource allocation on plant physiology.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

Benefits: 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.

Information\Technology Transfer:
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:

			1996 REQUEST	
			MT. VERNON	VANCOUVER
01	Wages		$4,600	$4,600
03	Supplies and Services		750	750
04	Travel		500	250
07	Benefits (16%)		736	736
LOCATION SUBTOTAL			$6,586	$6,336
		TOTAL	$12,922	
			Funded at $10,000	

BUDGET:

			1997 REQUEST	
			MT. VERNON	VANCOUVER
01	Wages		$5,000	$4,100
03	Supplies and Services		1,000	750
04	Travel		250	500
07	Benefits (16%)		750	650
LOCATION SUBTOTAL			$7,000	$6,000
		TOTAL	$13,000	

OTHER SUPPORT OF PROJECT:
Herbicides are typically provided by herbicide manufacturers. Additional funding for the use of glufosinate and carfentrazone to control primocane growth in red raspberries will be requested from the Washington State Commission on Pesticide Registration and an equal amount from the manufacturers of those herbicides.

PROJECT NO.: 13C-3555-5784

TITLE: ACHIEVING GREATER YIELD EFFICIENCY FOR WASHINGTON RED RASPBERRY PRODUCTION

PERSONNEL: **J. Scott Cameron** , Superintendent & Ass't Dean
Chuhe Chen, Stephen F. Klauer, Research Associates
WSU Research and Extension Unit, Vancouver

REPORTING PERIOD: 1995-97, *Termination Report (continuation proposed)*

ACCOMPLISHMENTS: *1995-97*

☑ Yield components quantified in the field in response to cane density.
☑ Yield components quantified in the field in response tying versus topping canes.
☑ Yield components quantified in the field in response to date of floricane removal.
☑ Yield components quantified in the field in response to a new trellis system.
☑ Environmental data collected in the field in order to study cultural phenology.
☑ Radioactive labeling studies continued.

RESULTS:

Cane Density. This study was instrumental in re-establishing what we know about the cultural biology of cane density management. Previous work done years ago was under a cultural management regime which included 'Willamette' and dinoseb – a shift to 'Meeker' and alternative cane management regimes has strongly impacted the dynamics underlying productivity. This study supported previous observations but also demonstrated some ways in which new cultural strategies could potentially increase yield by addressing specific limitations such as light penetration, training, etc.,. In this study, as cane density increased from four to 20 canes (4, 8, 12, 16, 20) per hill (cph), yield per cane decreased, while yield potential per area increased. While yield per cane may decrease 40% in response to going from 4 to 20 canes per hill, yield per area would increase as much as threefold. Fruit number is correlated with cane density, but fruit size was basically unaffected. Somewhat surprisingly, little change was observed in lateral length or numbers with density, however, we have observed that lateral length\numbers are greatly impacted by trellis design and caneburning.

Tying versus Topping. These practices have developed in different places for different reasons, and this study attempted to understand the potential advantages and disadvantages of each. In general the potential benefits to tying may happen in cycles and are strongly influenced by factors such as winter injury, cropping history, vigor, and training style. In certain years if productive, the tops of the canes can take an average yield to an outstanding one. If healthy and productive, the tops of the canes can alter intracane allocation as a result of increased numbers of laterals per cane. In this situation, lateral lengths decrease but increases in fruit number per cane can greatly increase yields. The impact of major fluctuations in cropping load appears to be a significant factor as well. Related research in our group has demonstrated that building appropriate carbohydrate reserves is critical and that heavy cropping over the length of a greatly expanded cane is something that must be considered in cultural management potentially with regard to cane control and density, and nutrition. In related work with winter injury, we have demonstrated that factors affecting bud break (blind or delay) and\or internal physiological conditions must be understood and better controlled as low levels of budbreak are more common than realized and are major detriments to productivity.

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. 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.

Phenology. While it takes quite a few years to collect enough climatological data to be a reliable model for plant or pest phenology, we are learning more about what data should be collected, how, and where. We are attempting to take the limited data we have at this time and compare it with general growth patterns, life cycles, etc.,. Through this work it has been clear that the value of the information is high and that the technology to develop what we need has become very inexpensive and easy to use relative to methods and hardware available even just several years ago.

Radioisotope labeling. While not a funded part of the project in recent years, we continue to develop better methods and capacity for doing this work. Our new facilities at WSU Vancouver designed for this work were not operating well this year but we anticipate that problems will be corrected in the coming months so that this work will continue to generate valuable information already developed with regard to resource allocation so that we can pursue studies dealing with the influence of crop load, cultural management and stress on those allocations and thus productivity.

New trellis design. Research with a new, machine-harvestable split trellis design has expanded quickly with significant promise and growing widespread interest. In its first years, yield potential increases from 25-50% have been documented from yield component analysis, with grower harvests showing increases from about 20-35%. Yield components of plants grown in the split trellis versus the conventional trellis are greatly altered in terms of architecture and reproductive capacity. The most critical feature of this system is the development of two canopies at the top wire where surface area increases significantly in a zone which has high levels of light exposure. This develops more crop in an environment in which fruit set and development is much higher than deeper in the conventional canopy. Another issue is primocane development in that greater light penetration early in the season may alter growth patterns. One field trial did not give significant yield increases in its second year, and though somewhat confounded by root rot, it is apparent that further research to optimize the system is essential. For example, too narrow a crossarm may limit benefits, while too wide an opening will cause damage during mechanical harvest. More specific data and information from this project will be provided at the meeting.

PROJECT NO.: 13C-3555-5784

YEAR INITIATED: 1991 CURRENT YEAR: 1998 TERMINATING YEAR: 2000

TITLE: ACHIEVING GREATER YIELD EFFICIENCY FOR WASHINGTON RED RASPBERRY PRODUCTION

PERSONNEL: **J. Scott Cameron** , Superintendent & Ass't Dean
Chuhe Chen, Stephen F. Klauer, Research Associates
WSU Research and Extension Unit, Vancouver
Tom Peerbolt, Peerbolt Monitoring, Inc.

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 1998)**

- ☑ Characterize yield potential of the red raspberry plant in relation to cultural practices and cane management regime.
- ☑ Study interplant\intraplant competition and its influence on cultural practices such as optimizing cane density, time of pruning and training systems.
- ☑ Initiate 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 significant success of research plot and grower-based trials and widespread industry interest, we propose to concentrate on this system as a primary project 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.

We will again have at least one site in Lynden to evaluate, if not more. In the southern part of the industry, in addition to a new eight acre trial established at the Vancouver research station, we will be assessing plots established in several farms in the southern end of the industry perhaps including Woodland, Vancouver and the Portland, OR, area. 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.

This year, several critical factors will be considered including crossarm width, mechanical harvest efficiency, and the development of canopy structure. Yield component and physiological measurements will be critical to assessing changes in the cultural environment. Yield component estimates, handpicked and machine harvest data will be compared in assessing these factors.

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

Radioactive Labeling Studies: Studies will use $^{14}CO_2$ as a radioactive tracer to determine where the products of photosynthesis go during different stages of seasonal growth. In particular, the role of root growth in competing with fruit for products of photosynthesis will be further characterized. This is particularly important in understanding the nature of below ground carbohydrate reserves in raspberry. We have demonstrated that senescing floricanes actually contribute carbohydrates for a significant period after harvest, thus we will continue to study this aspect of floricane biology and its impact on hardiness and productivity. Studies will be done in our new lab suite at WSU Vancouver using a 6' walk-in radioisotope hood.

Date of Floricane Removal. We will re-establish this study in a new and healthier field at Vancouver. Floricanes will again be removed in July, September, November and January. 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.

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 1997	Requested 1998
Temporary employees	$7,000	$7,500
Supplies and services	1,500	1,000
Travel	-----	800
Benefits (16% of 01)	1,120	1,200
TOTAL	**$ 9,620**	**$10,500**
	$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 1997, we have asked Mr. Tom Peerbolt to join us as a cooperator to oversee some of the harvest and data collection in on-farm plots.

OTHER SUPPORT OF PROJECT:
No other funded projects specifically address the topics of this research.

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

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 and G.E. Windom, Agricultural Research Technologist III, Washington State University, Puyallup Research and Extension Center

Reporting Period: 1997

Accomplishments: All scheduled treatments for 1997 were applied. Posts and trellis wires were installed to train primocanes for harvest in 1998. All plants were evaluated for phytotoxicity and disease severity.

Results: Despite above normal rainfall (conditions favorable for root rot) during winter 1996-97 few plants failed to send up new primocanes in the spring. By early summer primocanes began to wilt and percent wilt ranged from 0 to 32%. Unfortunately, disease severity was extremely variable and no treatment was significantly better than the untreated check. The fungus may not be as uniform as it has been in plots immediately adjacent to this planting. Plants treated with either Anchor (oxadixyl) or Acrobat (dimethomorph) produced more healthy primocanes per plant. Cane height data has not been collected yet. There was no evidence of phytotoxicity for any of the treatments.

Isolates of the pathogen obtained from plantings with a history of Ridomil use and others recovered from untreated plants were all sensitive to low rates of Ridomil. This suggests that the fungus has not developed resistance to Ridomil.

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

Year initiated: 1996 **Current year:** 1997 **Terminating year:** 1999

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

Justification: Phytophthora root rot can devastate red raspberry plantings especially new plantings. It is by far the most serious root disease of this high value crop in the Pacific Northwest. The rainy winters in this region favor the dissemination of spores of this water-mold fungus. While the disease is more common on heavy poorly drained soils, it also occurs on sandier soils. For a number of years growers have used the fungicide Ridomil for chemical control. More recently Aliette was registered for this use, but has not been as effective as Ridomil. Both have a role to play in controlling this disease chemically. A control program that includes both materials will help to delay the onset of resistance, especially to Ridomil.

It appears that the fungus at some sites may now be resistant to Ridomil. How widespread the resistant types are is unknown. The selection pressure for resistant types exists in all fields where that fungicide is and has been used. Identifying and eventually registering another fungicide for control will allow integrated approaches to control to be developed because of the added flexibility.

Objectives:

1. Continue to test the five newer fungicides for control of this root rot under field conditions and compare their performance to that of Riomil and Aliette.

2. Test isolates of the pathogen from various locations for resistance to Ridomil and related compounds such as oxadixyl.

3. If other new materials become available, test them in greenhouse pot tests to identify those with activity against this pathogen.

Procedures: A replicated field planting was established on naturally infested soil at the WSU-Vancouver Research and Extension Unit. Treatments were started at planting and have continued as scheduled. The repeat applications were made at intervals suggested by the various manufacturers. Because disease severity was so variable in the test planting the fungus will be added to soil around each plant during winter 1997-98. Plants will be evaluated for disease incidence and severity during the 1998 crop year.

Isolates of the pathogen were obtained from diseased plantings at several locations. These isolates will be tested in the laboratory for their sensitivity to Ridomil. They will also be tested against other members of the phenylamide group of fungicides to look for cross-resistance.

As other promising fungicides come along, they will be tested on potted plants in the greenhouse. The new greenhouses at WSU-Puyallup are now operational. It will be possible to keep the temperatures cool enough so that the root rot pathogen *Phytophthora fragariae* var. *rubi* will remain active in the soil.

Anticipated Benefits and Information Transfer: Identifying and ultimately securing a registration for a new fungicide will give growers an additional tool for control this root disease. This may also speed up the release of new red raspberry varieties as new releases may not need high levels of resistance if alternative methods of control are available.

Information from this applied research project will be used to support requests to the IR-4 program and the Washington Pesticide Registration Commission to fund larger scale field trials to generate the residue data required for submission to EPA. Results will also be disseminated at field days, grower meetings, and workshops. Details will be limited, however, because I feel reluctant to talk about products that are not legal to use on red raspberry. This is especially the case when a product is already registered for use on other crops and available in the marketplace.

Budget:

Allocation for FY1997-98	$1,600
Request for FY1998-99	
Timeslip	2,000
Operations (goods and services)	400
Travel	300
Projected needs	200
Meetings	40
Equipment	100
Employee benefits	180
Total	$3,220

Other Support of Project: None at this time. Until a promising chemical is identified I will not be able to request funds from either the Washington Pesticide Registrations Commission or the IR-4 program.

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: 1997

Accomplishments: Data was collected for the final time from the 1995 raised/flat bed planting. A new planting was established in 1997 using tissue culture propagated Meeker and Skeena plants. High rates of agricultural gypsum were tilled into the soil in some plots before bed shaping and planting. Raised beds were formed with a bed shaper used by raspberry growers. The height of the bed after settling was 12 inches above the surrounding soil. The plants established very well and by mid-October there were no differences between any of the treatments.

Results: Planting the susceptible variety "Willamette" on raised beds (top of the bed about 12 inches above the surrounding soil) dramatically reduced damage caused by the soil-borne fungus *Phytophthora fragariae* var. *rubi*. Disease pressure during winter 1996-97 was again high with only 33% of the original plants in flat beds still alive for the 1997 crop season (Table 1). In contrast, all of the plants in raised beds treated with Ridomil survived. While berries were not harvested for yield because there were so few plants in the flat beds fruiting cane performance was assessed. In flat beds most of the fruiting canes died before the berries were ripe (Table 2). In raised beds most of the fruiting canes were still alive after harvest, especially those that had been treated twice yearly with Ridomil. Fruiting canes in flat beds were few in number and short compared to those in raised beds (Table 3). Data from tensiometers installed at various depths demonstrated that soil in the raised beds was drier than soil in flat beds at the same depths throughout the growing season. In 1997 as in past years plants in raised beds resumed growth earlier in the spring than plants in flat beds. Apparently soil temperature is not responsible for the growth difference, as temperatures in raised beds were nearly identical to those in flat beds Figure 1).

It remains unknown why Ridomil failed to control the disease in flat beds as it had in previous trials at this site. Isolates of the pathogen taken from infected plants on this site remain sensitive to the fungicide.

Publications:

Bristow, P. R., and Windom, G. E. 1997. Impact of raised beds on Phytophthora root rot of red raspberry. APS Biological and Cultural Tests 12:49.

Bristow, P. R. 1997. Integrated control of root rot in red raspberry. Proc. Ore. Hort. Soc. 89:149-152.

Bristow, P. R. 1997. Raised beds and control of Phytophthora root rot of red raspberry. Proc. Lower Mainland Hort. Improv. Assoc. 39:73-76.

Appendix

Table 1. Plant survival.

Year	Survival, % Flat bed No Ridomil	Flat bed Ridomil	Raised bed No Ridomil	Raised bed Ridomil
1965	100	96	100	100
1996	54	46	79	100
1997	33	33	83	100

Table 2. Performance of fruiting canes in 1997 in flat and raised beds either treated with Ridomil or left untreated.

Performance category	No. of fruiting canes per plot[1] No Ridomil	Ridomil	No Ridomil	Ridomil
Canes did not grow in 1997	0.8 a[2]	0.5 a	3.8 a	2.0 a
Canes died during bloom	0.8 ab	0.0 a	1.8 b	1.3 b
Canes died before bloom	3.0 ab	0.0 a	5.8 b	3.3 b
Canes died during harvest (produced a partial crop)	3.8 a	1.0 a	9.0 b	8.5 b
Canes still alive after harvest (produced a full crop)	2.8 a	2.5 a	29.3 b	47.0 c
Total	11.2 a	4.0 a	49.7 b	62.1 c

[1] Each plot originally container 6 plants.
[2] Means followed by the same level within a row are not significantly different (P=5%).

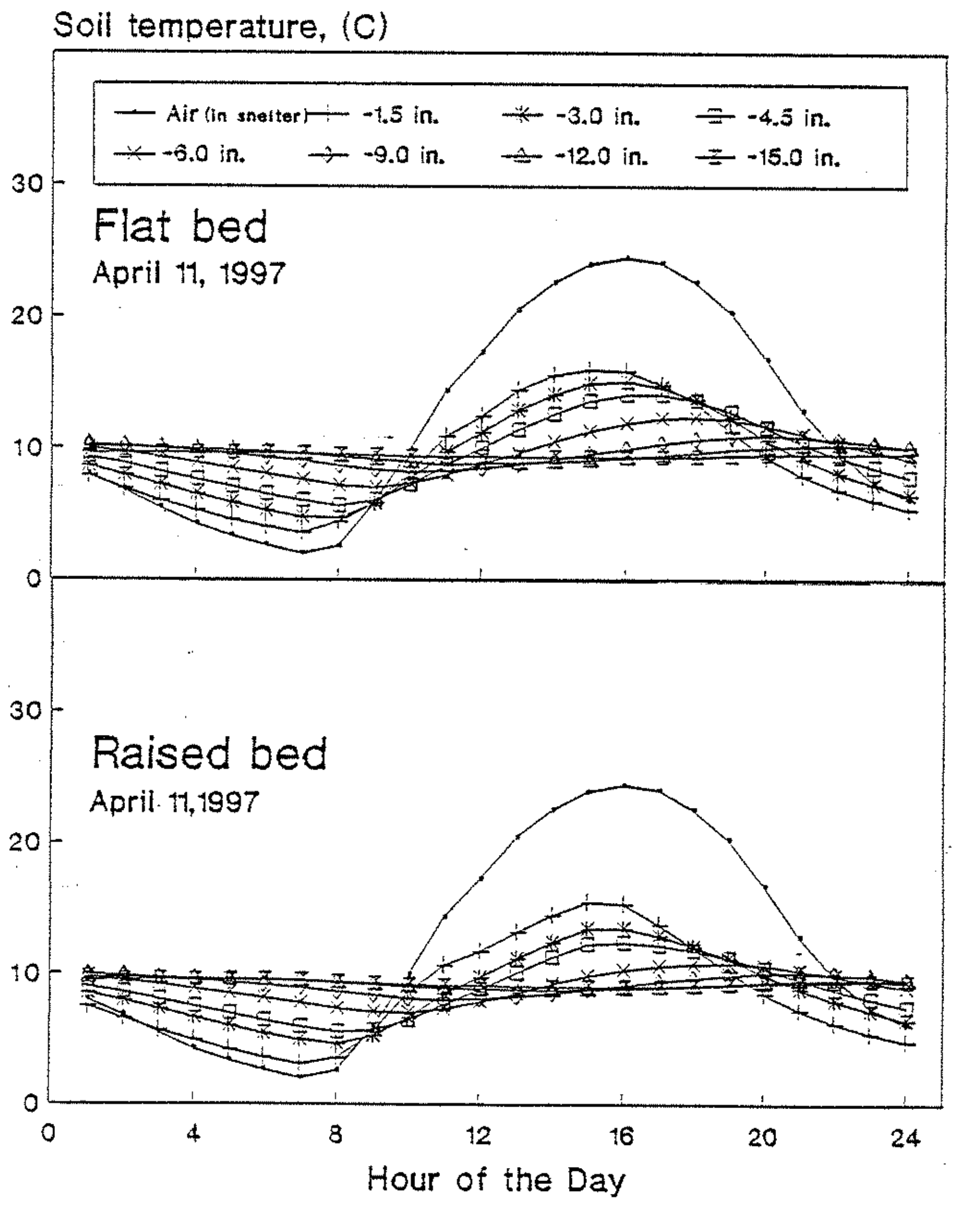
Table 3. Primocane growth and survival in 1997 in flat and raised beds either treated with Ridomil or left untreated.

Performance category	No. of fruiting canes per plot[1]			
	No Ridomil	Ridomil	No Ridomil	Ridomil
No. healthy primocanes per plot	8.6 a[2]	8.0 a	146.5 b	249.3 c
Percent primocanes wilted	9.6 a	6.3 a	18.7 a	11.6 a
Primocane length, in.	35.7 a	32.1 a	75.2 b	79.6 b

[1] Each plot originally contained 6 plants.

[2] Means followed by the same letter within rows are not significantly different (P=5%).

Figure 1. Temperature of soil at several depths below the surface of flat (top) and raised (bottom) beds.



Project No.: 13C-3761-6718

Title: Integrated control of Phytophthora root rot (formerly: The use of raised beds for control of Phytophthora root rot)

Year initiated: 1994 **Current year:** 1996 **Terminating year:** 1998

Personnel: Peter Bristow, Associate Plant Pathologist and Gwen Windom, Agric. Res. Tech. 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 control measure 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 metalaxyl (Ridomil) and it has successfully controlled the disease at many sites. 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 compound. Fosetyl-Al also has activity against *P. fragariae* var. *rubi*, but it has not been as effective as metalaxyl. Newer compounds are being tested, but the results will not be known until 1998 at the earliest. Even if promising products are identified, it will take time (years) to move them through the approval process. Efforts to breed for the high levels of resistance needed have been frustrating. Even the most resistant source identified to date yielded more when treated with metalaxyl. Progress is being made in combining resistance with desirable horticultural traits, but it takes time and there are no shortcuts.

Recently, we demonstrated that growing the crop on ridges dramatically lowered the incidence and severity of the disease at a site where the soil is naturally infested with the fungus and disease pressure is very high. Combining chemical control (metalaxyl) with the raised beds improved plant growth even more. Researchers in the eastern U.S. showed that incorporating high rates of gypsum into the soil prior to planting suppressed this disease. At this time it is unknown if this practice will be effective in the soils of the Pacific Northwest. Integrating several practices should be beneficial in a number of ways. First, it will give growers the highest level of control possible. Also, it will reduce the risk of the pathogen developing resistance to fungicides that are approved for this use. Approaching root rot control in an integrated way will give growers the greatest number of options.

Objectives:

1. 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. Metalaxyl (Ridomil) applied twice yearly vs. no fungicides.

Procedures: A field trial was established on a site with a history of Phytophthora root rot. Sixteen treatments will be evaluated with each treatment being replicated 3 times. Gypsum was applied and worked into the soil of designated plots before bed shaping and planting. Soil pH will be determined for plots with and without the addition of gypsum. Raised beds were formed prior to planting. Tensiometers will be placed in both raised and flat beds to monitor soil moisture. Ridomil was and will be sprayed on the soil surface immediately before rain or irrigation. During 1998 symptoms will be recorded, disease incidence and severity evaluated, and cane growth measured at the end of the season.

Anticipated Benefits and Information Transfer: Testing different control strategies individually and in combination will allow the identification of approaches that maximize disease control. Identifying non-chemical control measures should help to maintain the useful life of effective fungicides that are registered for this use. Because soil types that are ideal for growing red raspberries are limited, sites that become infested with the pathogen could still be used to grow the crop.

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

Budget:

Commission funding for FY1997-98	$3204
Request for FY1998-99	
Timeslip labor	1,900
Operations (goods and services)	1,000

Travel	
Projected needs	300
Meetings	100
Employee benefits	360
Total	$3,560

Other Support of Project: None at this time.

Project No.: 13C-3761-6784 (Termination report)

Title: Biology and importance of a cane dieback disease caused by the fungus *Siematosporium lichenicola*

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

Reporting Period: 1997

Accomplishments: The four experiments initiated last summer were terminated in July 1997 when the plants were destructively sampled for data collection. The experiments were:

1. 'Willamette' primocanes were inoculated on seven dates between mid-June and early-September to see if cane age influences susceptibility.

2. Primocanes of 3 different varieties were inoculated on two dates with three isolates of the fungus. The purpose is to determine if there are differences between varieties and/or isolates of the fungus.

3. In this test, we want to find out if canes need to be wounded before the fungus can establish an infection. Two isolates of the fungus and three varieties were used for this experiment.

4. Petioles of primocane leaves on three cultivars were inoculated to determine if the fungus enters the cane by growing down the petiole.

Results: By July 1997 none of the symptoms associated with this disease in the field were observed on any of the potted test plants. Canes did not become discolored nor did the bark split and crack, even at the point of inoculation. There was some internal discoloration of the vascular tissue but it was no different than that observed on the wounded (no fungus added) control canes. Spores of the fungus *Siematosporium lichenicola* were detected on virtually every cane regardless of whether the cane had been inoculated with the fungus the previous summer or not. Apparently conditions in the screenhouse allowed the fungus to produce and disseminate spores but were unfavorable for disease development. In the laboratory low rates on liquid lime sulfur prevented the germination of *Siematosporium lichenicola* spores.

Project No:

Title: Engineering genetic resistance to root weevils, twospotted spider mites, and root-lesion nematodes in red raspberry.

Year initiated 1995 Terminating year 1999 Reporting period 1997

Personnel

Dr. Thierry C. Vrain, Principal Investigator.
Pacific Agri-Foods Research Centre, Agriculture and Agri-Food Canada
Summerland, B.C. V0H 1Z0 Canada.
Phone (250) 494 6398 Fax (250) 494 0755 Email vraint@em.agr.ca

Dr. Basdeo Bhagwat, postdoctoral fellow (tissue culture).
Dr. Sherry Wilson, postdoctoral fellow (molecular genetics).
Ms Susan Wahlgren, technician (tissue culture).
Dr. David Raworth, collaborator, (entomology).

Accomplishments

The research was delayed by faults in the new tissue culture facility of the Pacific Agriculture Research Centre where the program moved from Vancouver in the fall of 1996. However, as stated in the proposal for 1997, we are still delivering functionnally transformed raspberry plants expressing a proteinase inhibitor (OCI) and a lectin (GNA). We have constructed new transformation vectors with either the lectin or the proteinase inhibitor genes under the control of a wound inducible promoter from Asparagus (AoPR1 - Asparagus officinalis Plant Resistance gene # 1)
Comet raspberries have been established in tissue culture that were transformed with *Agrobacterium tumefaciens* to express OCI, a proteinase inhibitor gene from rice and a lectin from snowdrop. Putative transformants have been regenerated on glufosinate herbicide medium), and their molecular characterization is in progress.

Results

We have designed a new series of transformation vectors, with features different from those of the previous vectors where antibiotic resistance was the selection marker for transgenic plants. The new selection is from glufosinate herbicide resistance, which becomes an added feature available in the field. The new promoter driving the pests resistance genes (cystein proteinase inhibitor and mannose binding lectin) is a wound inducible promoter isolated from asparagus. It gives the advantage that the defense molecules are only expressed in tissues under attack by insects and nematodes.

While most lectins are toxic to many insects, many are also toxic to mammals. The lectin from snowdrop has little or no toxicity against mammals, and has been shown to be toxic against several insects, and against root-knot and root-lesion nematodes. We are testing the lectin gene from snowdrop and the proteinase inhibitor from rice. The mechanics of action (deleterious effects) of lectin genes is not known and it is different from the effects of proteinase inhibitors on digestive enzymes of insects and nematodes. We now have a dual resistance, from two genes with different mechanisms of action, that will be more durable, ie. the pests will find it very difficult to overcome the resistance engineered in our raspberries.

We had to analyze coding sequences and restriction sites to orient and manipulate the two genes and incorporate them in a cassette with the selection genes, the promoters and terminators. We are using *Agrobacterium* transgenesis. We use a binary vector with eukaryotic promoter and termination sequence elements, as well as the left and right border sequences for *Agrobacterium*-mediated transgenesis into raspberry.

We have regenerated transgenic raspberry plants (shown by selection on Basta herbicide medium and PCR tests). We are presently analyzing these plants to check that the proteinase inhibitor and lectin genes are integrated (southern blots), that the proteinase inhibitor or the lectin are expressed in the roots, with full biochemical functionality (enzyme inhibition assays). These plants will undergo biossays with root-weevils, nematodes and spider mites in 1998 and 1999 depending on funding.

Project No:

Title: Engineering genetic resistance to root weevils, twospotted spider mites, and root-lesion nematodes in red raspberry.

Year initiated 1995 **Terminating year** 1999 **Proposal for 1998**

Personnel

Dr. Thierry C. Vrain, Principal Investigator.
Pacific Agri-Foods Research Centre, Agriculture and Agri-Food Canada
Summerland, B.C. V0H 1Z0 Canada.
Phone (250) 494 6398 Fax (250) 494 0755 Email vraint@em.agr.ca

Dr. Basdeo Bhagwat, postdoctoral fellow (genetic transformations).
Dr. Savita Visal, postdoctoral fellow (molecular biology)
Ms Susan Wahlgren, technician (tissue culture).
Dr. David Raworth, collaborator AAFC (entomology).

Objectives

This research project is developing transgenic red raspberry plants resistant to the black vine weevil, twospotted spider mites, and to the root lesion nematode. We are adapting a novel approach to the control of insect and nematode pests, engineering the production of proteinase inhibitors from other plants into transgenic raspberry plants. The objective of the fourththird year of this research project will be to regenerate transgenic raspberry plants cv Comet expressing OCI, a cystatin from rice, and GNA, a lectin from snowdrop. After molecular characterization, the transformed plants will be multiplied and transferred to a greenhouse. In the fourth year, the plants will be assayed for levels of pest resistance against twospotted spider mites, black vine weevils, and root lesion nematodes.

Justification

Plantings of the Pacific Northwest, are infested with a complex of species of root weevils, primarily the black vine weevil (*Otiorhynchus sulcatus*), twospotted spider mites *Tetranychus urticae*, and the root lesion nematode (*Pratylenchus penetrans*), or a combination of theses pests. Root weevils, especially the black vine weevil, are of concern because larvae damage raspberry roots and adults contaminate raspberry fruit at harvest. Larvae girdle the roots, which often weakens or kills the plant. Adults that are shaken from the plant during harvest end up in the fruit bins and may cause the fruit to be downgraded. If weevil larvae could be prevented from feeding on raspberry roots, populations of adult weevils would also be reduced or eliminated and fruit contamination would be minimized.

The two-spotted spider mite is a significant pest on raspberry crops along the Pacific Rim. Driscoll's Small Fruits Crop Advisory Committee flagged the mite as a top priority, and gave it equal priority with aphids and weevils on raspberry. Spider mite outbreaks in commercial raspberry fields often result in partial or complete defoliation of the primocanes. Dr. Raworth has shown that primocane defoliation can reduce yields the following year by up to 50%. Other work has shown that the effect depends on winter severity. Root-lesion nematode damage is very insidious, unlike the kind of damage from most other pests and pathogens, and often goes unnoticed. Chemical control is at present the only means of reducing nematode density in soil before planting raspberry.

Genetic resistance against these pests has either not been found or is difficult and expensive to introduce into raspberry germplasm (Daubeny and Vrain, 1986 and 1994). *The development of insect pests is delayed or arrested when feeding on foliage and roots of plants containing proteinase inhibitors and certain lectins.* Published technology exists to transfer certain resistance genes (proteinase inhibitors) from higher plants into raspberry.

Objectives

This research project is developing transgenic red raspberry plants resistant to the black vine weevil, the twospotted spider mites, and the root lesion nematode. We are adapting a novel approach to the control of insect and nematode pests, by engineering the expression of proteinase inhibitors and lectins in root tissues wounded by the nematodes into transgenic raspberry plants.

The objective of the fourth year of this research project is to complete the genetic analysis of transgenic raspberry plants, and if time permits to bioassay for levels of pest resistance against black vine weevils, twospotted spider mites and root lesion nematodes.

Procedures

We constructed new binary transformation vectors containing a wound inducible promoter, AoPR1 from asparagus (*Asparagus officinalis* Plant Resistance gene # 1), driving the cysteine proteinase inhibitor gene OCI from rice, or the mannose binding lectin GNA from snowdrop, with a nopaline synthase terminator from *Agrobacterium tumefaciens,* with *bar*, a gene encoding phosphinotricin acetyltransferase for glufosinate herbicide resistance, controlled by the 35S promoter from the Cauliflower mosaic Virus, with a Tobacco Mosaic Virus leader sequence and an Alfalfa Mosaic virus enhancer sequence, and the nopaline synthase terminator from *Agrobacterium tumefaciens*. The constructs were inserted in the T-DNA (transfered) region of a binary vector for transfer into disarmed *Agrobacterium tumefaciens*.

Comet raspberry leaf tissue is inoculated, and regenerating transformed calli are cultured, and shoots are rooted on appropriate media. PCR test show which raspberry plants were transformed; southern blots will show how many copies of the proteinase inhibitor gene were integrated in the plants's chromosomes; western blots will show which plants express a functionnal protein; and enzyme inhibition assays will show how effective the OCI protein is in raspberry root tissues. Plants with a high level of transgene expression will be bioassayed with nematode and insect pests.

Budget: 1998-1999

Salary of tissue culture technician	$ 5,000
Material and supplies	$ 1,000
Travel	$ 500
Total	**$ 6,500**

Other support 1997-1998

British Columbia Raspberry Development Trust Fund	$ 1,600
Oregon Raspberry Commission	$ 3,000
Matching Investment Initiative of AAFC	$ 17,000

Equivalent support are expected from the other three agencies in 1998-1999.

Progress Report:
Title: Transformation of Raspberry with the Coat Protein of Raspberry Bushy Dwarf Virus

Robert R. Martin, USDA-ARS, 3420 NW Orchard Ave., Corvallis, OR 97330; Richard Bestwick, Agritope Inc., 8505 SW Creekside Place, Beaverton, Oregon 97008
Reporting Period: 1997

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. Based on work published on other plant viruses we have chosen to make our mutants in the first half of the movement protein as this appears to be the region involved in modifying the size of plasmadesmata (channels between cells) that allows for viruses to move from cell to cell. 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 first construct into 'Meeker' raspberry has been carried out and the first set of transformants are in tissue culture. These transformants are in the second cycle of regeneration on selective media to ensure that they are truly carrying the gene of interest and that we are not dealing with chimeric plants (plants having the gene present in only some of its tissues, thus a single plant with two separate genotypes). After the second cycle of regeneration is completed the plants will be rooted, established in a greenhouse and grafted with RBDV.

The mutations that we are using for the movement protein are:

1. Wild type movement protein, this is unchanged from what the virus normally produces, but is now made by the plant in the absence of virus (this is a control since it should not make resistant plants).
2. Removal of the start codon and insertion of two stop codons where amino acids 3 and 6 would normally be. This ensures that we will have the RNA of the gene present but no protein produced in the plant. This approach of developing resistance is known as cosuppression and has been demonstrated for several plant viruses.
3. Deletion of amino acids 2-6 in the movement protein
4. Deletion of amino acids 5-14 in the movement protein
5. Deletion of amino acids 37-42 in the movement protein

We have also developed constructs with the coat protein gene of RBDV.

Project No.: 13C-3761-3785

Title: Sources and importance of overwintering inoculum of the yellow rust fungus (*Phragmidium rubi-ideai*)

Personnel: Peter Bristow, Associate Plant Pathologist, WSU-Puyallup Research and Extension Center, and Geoffrey Menzies, IPM Specialist, WSU-Nooksack IPM Project

Reporting period: 1997

Accomplishments: Trials were conducted at sites in Whatcom Co. to determine if: i) removal of leaf litter from between the canes and ii) the use of liquid lime sulfur and ferbam would reduce disease severity. Limited information was obtained from these trials because disease pressure was so low in 1997 (despite the disease being prevalent in both sites in 1996). From other sites where disease pressure was higher, we were able to demonstrate where on the plant initial infections occurred and what impact trellis design had on disease development.

Results: In fields where last year's leaves were trapped between canes when they were tied to the top trellis wire yellow rust was the most severe on laterals at and just below the wire (Table 1). In contrast, where leaves were allowed to drop to the ground before cane bundles were tied to the trellis, the disease was the most severe on laterals near the base of the plant. The oldest leaves on laterals (those closest to the cane) were attacked (Table 2). These leaves were present when primary inoculum was produced. Younger leaves remained healthy because they formed after inoculum was available.

Cane burning eliminated the early primocames and replacement canes escaped the aecial stage because they emerged after primary inoculum was produced. Where primocane vigor was not controlled aecia were observed on the oldest primocane leaves at the same time they appearred on fruiting cane leaves.

Pustules (uredinial stage) appeared in late-June on leaves of both primocanes and fruiting canes. They first appeared near the top of fruiting canes and progressed downward. For primocanes pustules first appeared on the lower leaves and then moved upwards(Table 3)

Trellis design (single top wire vs. split 2-top wires) had no impact on yellow rust development on either type of cane (Table 4).

Only low numbers of teliospores were found on the surface of canes during February and March (Table 5). Numbers near the top of the canes was no higher than that found on the middle and the bottom sections. Spores failed to germinate when cane sections were incubated under temperature and relative humidity conditions favorable for germination, suggesting teliospores on the surface of the canes may not survive from one year to the next. At site M (Table 6) removing leaf litter while the canes were still dormant in late winter did not lower the number of aecia produced. A delayed dormant application of Sulforix with or without a subsequent application of Ferbam reduced the incidence of the aecial stage. Ferbam used alone was no better than the untreated check.

Publications:

Bristow, P. R. and Windom, G. E. 1997. Reaction of selected red raspberry genotypes to yellow rust, 1994-1995. APS Biological and Cultural Tests 12:50.

Appendix

Table 1. Severity of yellow rust (aecial stage) on laterals collected from different regions on fruiting canes[1].

Location of lateral	Number of aecia per 10 laterals
Top of arch	59.7
At top trellis wire	198.3
1 foot below wire	166.7
2 feet below wire	62.7
3 feet below wire	51.0

[1] Laterals collected on 21 May 97.

Table 2. Development of yellow rust (aecial stage) on fruiting lateral leaves[1].

Position of Leaf on Lateral[2]	% Leaves Missing	% of Leaves Present With Aecia	No. of Aecia per Leaf
1	100	-	-
2	88	100	1.0
3	67	88	7.4
4	13	94	5.0
5	6	73	3.9
6	0	50	1.9
7	0	31	1.4
8	0	13	0.1
9	0	13	0.3
10	0	0	0
11	0	0	0
12	0	0	0
13	0	0	0

[1] Laterals collected at or just below the trellis wire.
[2] Position 1 is closest to the cane while 13 is at the tip of the lateral.
[3] The average lateral on 13 May 97 was 21.3 inches long and had 12.3 leaves.

Table 3. Severity of yellow rust (uredinial stage) on primocane leaves at three positions on the canes and for two trellis designs.

	Disease severity rating[1]	
Leaf position of the cane	Single wire trellis	Split 2- wire trellis
Top	1.0 a	0.9 a
Middle	1.2 a	1.2 b
Bottom	1.5 b	1.4 b

[1] Disease severity rating scale: 1 to 4; 1= a few uredinia per leaf, and 4= numerous uredinia per leaf.

Table 4. Development of yellow rust (uredinial stage) on primocanes grown on trellises of two designs.

Factor measured[1]	Single Wire Trellis	Split 2-Wire Trellis
Primocane length, in.	70.0	82.9
No. of nodes per cane	23.2	29.0
No. leaves per cane	14.7	16.8
% leaves with uredinia	39.3	47.0

[1] Canes collected 26 Jun 1997.
[2] No aecia present.

Table 5. Number of overwintering teliospores at three different positions on the surface of canes.

	No. of Teliospores per cm^2					
	Site M			Site N		
Position on cane	19 Feb	5 Mar	14 Mar	19 Feb	5 Mar	14 Mar
Top	12.2 a	20.1 a	18.5 a	2.2 a	2.6 a	0.9 a
Middle	25.9 a	18.8 a	3.4 a	4.3 a	1.5 a	1.0 a
Bottom	17.1 a	23.1 a	17.9 a	6.8 a	0.7 a	2.6 a

Table 6. Impact of leaf litter removal and the application of liquid lime sulfur and ferbam on yellow rust (aecial stage)[1].

Treatment	Leaf litter removed (3 Mar)	Sulforix applied (14 Mar)	Ferbam applied (25 Apr)	No. of aecia per plot: Site M	No. of aecia per plot: Site N
A		-untreated check-		69.7 a	9.5 a
B	X			52.3 a	5.3 a
C		X		14.0 b	6.8 a
D			X	67.7 a	10.3 a
E		X	X	8.3 b	5.8 a
F	X	X		-	5.0 a
G	X		X	-	4.3 a
H	X	X	X	-	3.8 a

[1] Data collected 2 May 1997.

Project No.: 13C-3761-3785

Title: Sources and importance of overwintering inoculum of the yellow rust fungus (*Phragmidium rubi-idaei*)

Year initiated: 1997 Current year: 1998 Terminating year: 1999

Personnel: Peter Bristow, Associate Plant Pathologist, WSU-Puyallup Research and Extension Center, and Geoffrey Menzies, IPM Specialist, WSU-Nooksack IPM Project

Justification: Yellow rust has become an increasingly important disease in a number of red raspberry fields in western Washington and Oregon. Research supported, in part, by this Commission showed that there are three races of the pathogen and all are capable of attacking certain varieties which were previously resistant to the disease. Both Meeker and Willamette are now susceptible to these races. Meeker was previously described as having strong incomplete resistance of the "slow-rusting type". In short, it was susceptible, but sustained little damage because the disease developed so slowly. There is evidence that current races have overcome the "slow-rusting" trait in Meeker. Yield losses occur when the leaves on laterals of fruiting canes are attacked causing berries to shrivel before they ripen. The more common situation is for leaves on the primocanes to become rusted. It is unclear what impact primocane leaf infections have on the productivity of these canes the following year.

The pathogen only overwinters as teliospores on rusted leaves and for this reason sanitation has been the primary approach to control. Cultivation buries infected leaves removing the overwintering inoculum. Some teliospores remain attached to canes by a sticky appendage. But, it is unclear how important these spores are in initiating the disease in the spring. Usually, leaves at the base of canes are the first to show symptoms in the spring. Yellow rust then moves upward in the plant as the season progresses. In recent years, the first symptoms in the spring were on new floricane leaves along the top trellis wire. The source of inoculum for these infections appears to be the mass of last year's leaves trapped between canes where they are bundled together and tied to the trellis. The trapping of leaves is linked to growers tying primocanes to the trellis before the leaves have dropped naturally.

Objectives: 1) To determine the importance of teliospores in the knot of leaves along the top trellis wire. 2) To determine the distribution and survival of teliospores on the surface of overwintering canes, and 3) To determine what effect fungicides applied in the spring have on disease development.

Procedures: Experiments will be conducted in a commercial field with a history of the disease. Leaves trapped between canes will be removed by hand in certain areas and left in placed in others. Disease progress will be followed through the 1998 crop season. During the winter and early-spring canes will be collected and examined microscopically to determine the density of teliospores on the surface. Cane sections will be incubated in moist chambers and then examined to determine spore viability. The effectiveness of liquid-lime sulfur, copper hydroxide, and a new triazole fungicide will be determined.

Anticipated Benefits and Information Transfer: Modifications in cultural practices used to grow red raspberries have influenced where the yellow rust fungus overwinters. We anticipated that this research will demonstrate that primary infection in the spring occurs along the top trellis wire and that the inoculum comes from germinating teliospores on leaves trapped between canes where they are tied to the trellis. These changes in cultural practices have had little impact on the disease when present varieties were resistant to the prevalent races. As races which can attack these varieties have been selected for the situation as changed. If yellow rust cannot be adequately controlled by chemical or other means, cultural practices may have to modified so that sanitation will become practical again.

Information will be made available in reports, at field days, through presentations at and proceedings of horticultural association meetings and changes in the annually updated "Pest Management Guide for Commercial Small Fruits" bulletins.

Budget:

Time slip	$2000
Operations	400
Travel	
Project needs	500
Meetings	50
Equipment	100
Employee Benefits	380
Total	$3430

Other Support of Project: No other sources of funding are currently available.

Project No.: 13C-3761-8784

Title: Determining when *Didymella applanata* (spur blight) infects red raspberry canes in NW Washington.

Personnel: Peter Bristow, Associate Plant Pathologist, and Gwen Windom, Agricultural Research Technologist III, WSU-Puyallup Research and Extension Center, and Geoffrey Menzies, IPM Specialist, WSU-Nooksack IPM Project

Reporting period: 1997

Accomplishments: At the request of the Commission the proposal originally submitted (Influence of trellis design on cane and fruit diseases) was revised. The main objective of the new project was to determinine when canes become infected by fungi that cause cane diseases (particularly *Didymella applanata* the spur blight pathogen). The practical goal was to improve the timing of fungicide applications. Better timing would help maximize disease control and minimize fungicide use. Trials were conducted in three Meeker fields in the Northwood area of Whatcom County. A tank mixture of Captan and Rovral was applied to different plots on six dates between early-May and mid-July to protect leaves and canes for different periods. By assessing disease severity on both primocanes and fruiting canes we determined when infection occurred during the 1997 crop season.

Results: Symptoms were first noticed on leaves of fruiting cane laterals in early-July. Leaves in certain plots were yellow and had numerous necrotic spots associated with the veins. This foliar stage of spur blight partially defoliated laterals on plants in the untreated plots and in plots with poor fungicide timing. This stage of the disease was controlled when the fungicide mixture was applied on May 16 and May 30 (Table 1). Applications made before or after those dates gave partial or no control. The typical wedge-shaped lesions found on leaves of primocanes did not appear until mid-July. In late September primocanes were evaluated for cane diseases. Spur blight was the most predominant disease with the occasional cane lesion caused by *Botrytis cinerea*. Primocane leaves at nodes below 5 feet became infected between mid-May and mid June (again fungicides applied on May16 and 30 protected plants for this period)(Table 2). During this period mean primocane height rose from under 1 foot to just over 4 feet. Canes became infected again in late-June but mainly at nodes above 5 feet on the canes. These nodes and leaves had not developed when the May 16 and 30 fungicide applications were made (primocane did not reach the height of 5 feet until mid-June).

Presentations:

Cane disease research update. WSU-Lynden Satellite Station Open House, September 18, 1997.

Appendix:

Table 1. Disease severity rating for leaves on laterals of fruiting canes protected by fungicides for different periods[1].

Fungicide application dates	Disease severity rating[2]		
	Site H	Site N	Site T
Untreated check	2.8 a	3.0 a	2.5 a
02 May and 16 May	0.8 c	0.8b	0.2 d
16 May and 30 May	0.0 d	0.0 c	0.7 cd
30 May and 13 Jun	0.5 cd	0.5 bc	1.2 bc
13 Jun and 27 Jun	1.8 b	1.2 b	1.7 abc
27 Jun and 11 Jul	2.8 a	2.5 a	1.7 abc
11 Jul	3.0 a	3.0 a	2.0 a

[1] Data collected 11 Jul 1997.
[2] Disease severity rating scale: 0-3. 0=healthy, and 3=extensive leaf damage and defoliation.

Table 2. Effect of fungicide timing on the severity of spur blight on primocanes[1]

Fungicide application dates	% nodes infected	
	below 5 ft.	above 5 ft
Untreated check	82 a	10 a
02 May and 16 May	45 cd	7 abc
16 May and 30 May	39 d	5 c
30 May and 13 Jun	55 bc	10 a
13 Jun and 27 Jun	54 bc	6 bc
27 Jun and 11 Jul	64 b	6 bc
11 Jul	77 a	8 ab

[1] Primocanes collected at Site N on 27 Sep 1997.
2 Mean number of nodes below 5 ft. = 18.6
3 Mean number of nodes above 5 ft = 35.1

Project No.: 13C-3761-8784

Title: Determining when cane disease pathogens infect red raspberry in NW Washington

Personnel: Peter R. Bristow, Associate Plant Pathologist, WSU-Puyallup Research and Extension Center, J. Scott Cameron, Associate Horticulturist, WSU-Vancouver Research and Extension Unit, and Geoffrey Menzies, IPM Specialist, WSU-Nooksack IPM Project

Year Initiated: 1997 **Current Year:** 1998 **Terminating Year:** 1999

Justification: Spur blight caused by the fungus *Didymella applanata* adversely impacts the red raspberry plant in a number of ways. Buds at infected nodes on primocanes are smaller and produce shorter less productive lateral the following year. Some of the infected buds may not break at all particularly if the winter has been extremely cold. The fungus can also attack fruiting canes. When leaves on laterals are attacked they become yellow with numerous brown spots. Infected leaves also drop prematurely. The loss of leaves markedly reduced the ablility of the lateral to supply the needed carbohydrate to developing berries. When conditions are wet and warm flower stalks and/or the entire lateral may be girdled. Fungicides such as Captan and Rovral are effective against this pathogen, but questions remain as to the number and timing of applications. The pathogen has two spore stages and researchers in the United Kingdom found that most spores are produced in late spring but some are still present in August. The latter information maybe the basis for certain fungicide labels recommending applications after harvest.

Results of our 1997 field trial identified a single infection period for fruiting cane leaves and laterals. The period was the same for primocane leaves with an additional or possibly extented period for younger leaves on the top portion of primocanes. Developing tools to predict infection periods will permit the more precise timing of fungicide applications.

Objectives:

1. To determine when primocanes and fruiting canes become infected by *Didymella applanata*.

2. To determine when the fungus produces inoculum (both ascospores and conidiospores).

3. To monitor the micro-environment of the plant canopy and the macro-environment of the test site.

4. Test for relationships between the environment, inoculum production, and infection.

Procedures: Experimental plots will be established in a commercial field of 'Meeker' red raspberry in Whatcom County with a history of spur blight damage. Plots will be sprayed with a mixture of Captan and Rovral on different date to provide protection for various periods of the crop season. Disease incidence and severity data from these plots will be used to determine when infection occurred. A volumetric spore trap will be operated continuously to trap airborne ascospores. Cane sections will be collected on a regular schedule and fruiting bodies of the fungus examined microscopically for spore development. HOBO temperature and relative humidity recorders will be used to collect data on the micro-environment of the plant canopy. Other instrument will record factor such as rainfall leaf wetness and solar radiation. Computer statistical programs will be used to establish relationships between biological and environmental data.

Anticipated Benefits and Information Transfer: The period when infection takes place each year may vary as will the times when fungicides need to be applied to obtain control. By repeating a portion of the work done in 1997 we will be able to see if variation exists. More importantly, in 1998 we will begin to collect the necessary data for developing models to predict inoculum production and infection periods. The practical goal will be to maximize control and at the same time minimizing the amount of chemical used. Information generated by this project will be disseminated in a number of ways including: grower meetings, workshops, IPM manuals, annually updated commercial pest control guides,and presentations at association meetings.

Budget:

Allocation for FY1997-98	$5,000
Request for FY1998-99	
Timeslip	$2,700
Operations	400
Travel	
Projected needs	800
Meetings	100
Equipment	800

Employee benefits	245
Total	$5,045

Other Support for this Project: No other sources of funding are available or pending.

Project No.: New

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

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

Personnel: Lynell K. Tanigoshi, Associate Entomologist, WSU Vancouver REU and **Arthur L. Antonelli**, Extension Entomologist, WSU Puyallup REC

Justification: The orange tortrix, *Argyrotaenia citrana,* 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 pyrethoids at great risk within the next 24 months.

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 that will involve strategies such as mating disruption and conservation of a complex of primary parasitoids and predators identified in commercial fields of red raspberry in the Pacific Northwest.

Objectives:

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

2. Evaluate pheromone traps as decision making indicators for: aspects of orange tortrix field distribution, estimate of male emergence, their population density and spray recommendations (timing).

Procedures:

1. Replicated field trials will be conducted at several known infestation in Clark and Cowlitz counties and possible sites on Sauvie Island and in Multnomah County, OR.

2. Various densities of pheromone traps will be in place by 1 April.

3. In addition to the provisional treatment threshold of 25 moths/trap/week, we will conduct weekly visual examinations of terminal foliage for early larval instar activity and beating tray sampling. These sampling methods will provide empirical data to assess impacts of standard and biorational treatments on the natural enemy complex.

4. Treatments will be full coverage sprays applied with a tractor mounted 6 tank plot sprayer with an over the row boom using 14 D3-45 TeeJet nozzles per row at 200 psi, delivering 130 gal/acre at 2 mph.

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 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, chlorphenapyr) are low risk insecticides, a mechanism has been provided by USEPA to fast track them for federal registration. Results will be disseminated where appropriate to grower meetings, workshops and field days through the auspices of cooperative extension.

Budget:

		1998
01	Temporary employees	$2,000
07	Employee benefits (16% of 01)	320
	Total	$2,320

PROJECT NO: New

YEAR INITIATED: 1998-1999, CURRENT YEAR 1998-1999,TERMINATING YEAR: 1999-2000

TITLE: Heritability and Sensory Impact of Principal Flavor Components in Red Rasperries

PERSONNEL: John Fellman, WSU-Pullman Postharvest Lab
D.S. Mattinson, Associate in Research
Graduate Students, Work-Study and Timeslip Employees

Cooperators:
P. Moore WSU-Puyallup
John H. Thorngate, University of Idaho, Moscow

JUSTIFICATION

For uniform processing quality it is important to develop a data base of flavor and odor components across cultivars of berries. It is also important to know how harvest maturity affects flavor component content. Once the chemical measurements have been performed, an important, yet often overlooked aspect of flavor chemistry is establishment of the relationship between chemical content and sensory perception. By cultivar evaluation of these properties, processors will be able to "fine tune" berry, harvest, handling, and cultivar selection to meet quality criteria for a particular application. By determination of preharvest environmental influence on postharvest aroma quality, it will be possible to identify ideal growing sites in the Pacific Northwest for cultivars destined for special processing niches.

OBJECTIVES:

1) To determine heritability of principal flavor and odor-active components with sensory impact present in red and yellow raspberries from selected crosses.

2) Ascertain the relationship between flavor compound content/sensory impact to facilitate studies concerning the effects of genotype, cultural practices, maturity and postharvest handling on flavor perception in raspberries.

PROCEDURES:

This study will be focused on measuring differences in flavor and odor compound content from a series of *R. idaeus* crosses made in Dr. Moore's program at WSU-Puyallup. WSU1098 and 'Algonquin' have bee indentified as likely candidates for advancement, due to results obtained from our initial studies. This does not preclude use of other advanced material, as we are in the process of continual screening of the Puyallup samples for flavor quality. Likely breeding scenarios would include both maternal and paternal crosses with germplasm identifed for other quality attributes such as yield, color and firmness. Replicated samples will be harvested at commercial maturity and frozen for subsequent analyses. Purge-and-trap methods will be used for volatile component analysis. Raspberry tissue is crushed and 2.5 ml of juice diluted 1:1 with distilled deionized water. Samples are purged in a closed system for 5 min with helium, and water vapor condensed from the sampling stream by passing the vapors through a cryostat held at -10^{o}C. Samples are injected by cryofocusing at -90^{o}C using a commercial purge-and-trap injector (Chrompack International B.V. Middelburg, The Netherlands) modeled after that reported by Badings et al.(1985). Gas chromatographic separations are achieved using conditions reported by Mattheis et al.(1991), but the DB-WAX column diameter is 0.32 mm with 5.0 µM film thickness. Quantitation was achieved using flame-ionization detection. Positive identification of volatile molecules is facilitated by interfacing the gas chromatograph to a Hewlett-Packard 5971 Quadrupole Mass Spectrometer operated in the electron ionization mode at 70eV. Identification is via Wiley/NIST library match and injection of standard compounds. Raspberry ketone quantitation is achieved using the method of Borejsza-Wysocki, et al.(1992).

Sensory evaluation of berry samples and/or extracts will be conducted in the UI Food Research Center sensory evaluation laboratory. Equipment available includes sensory testing booths, sample perparation area, and conference room. The booths can accomodate up to six persons at one time, provide for either white or red light, and are under positive pressure ventilation to prevent aroma cross-contamination or incursion.

For sensory/instrumental statistical correlation analyses, we have a site license for PC-SAS. In addition Dr. Thorngate has the Partial Least Squares Regression Analysis software package, as well as Unscrambler (CAMO, Norway), which is designed to model the regression relationships between two sets of data(multivariate calibration and prediction). Dr. Thorngate has attended software workshops regarding this particular analysis package and has worked in collaboration with Dr. Harald Martens, one of the software authors.

LITERATURE REVIEW

Raspberry volatile components remain relatively unstudied. Identification of some principal components has been accomplished(Adams, et al. 1952). The "raspberry ketone" responsible for the characteristic odor and flavor is 1-(4'-hydroxyphenyl) 3-butanone (Braun and Heike, 1977). There are six major compounds accounting for approximately 80% of the aroma intensity in R. idaeus(Latrasse, 1982). Larsen and Poll(1990) determined the sensory thresholds of ten raspberry aroma compounds, which include raspberry ketone, α- and β-ionone, geraniol, and linalool that contribute to the characteristic aroma. Another recent study was that of Shamaila, *et al.*(1993) who confirmed the important sensory properties of alcohols, ketones, aldehydes and terpenes using chemical and sensory analysis. At least 4 other studies show similar results, and it is interesting to note that berries from northern climates seem to have higher sensory impact than those grown in lower latitiudes(Hokanen *et al.*,1980)

ANTICIPATED BENEFITS

For processing, IQF, and fresh-market quality, it is important to include information about flavor content as cultivar selections are advanced toward eventual release. The Red Raspberry Commission has listed IQF variety development as one of the plant breeding research priorities. Flavor is an important quality determinant. As mentioned previously, beneficial impacts will include increased information available to producers and processors regarding flavor components of red raspberries. Results will be disseminated by presentations at regional(PNW) meetings, to Commissioners, reports, as well as publications in relevant scientific literature.

FACILITIES: All major instrumentation and equipment are in place and described in the work plan.

PROPOSED BUDGET FY 1998

Timeslip Labor	2,000
Fringe benefits(9%)	180
Operating Expense	2,020
Equipment	0
Travel	1,000
Total	$5,200

BUDGET JUSTIFICATION

Majority expense is support for personnel responsible for most of the laboratory work. Other funds are requested for student labor for sample preparation, assistance with sensory analysis and data input. Operating expenses include liquid nitrogen purchases and associated reagents, gases, etc. for volatiles analysis.
Travel monies for research reporting and sample acquisition are included. Breakdown as follows:

Sampling trips Pullman-Puyallup (1)	$500
Research reporting at local/regional Meeting	$500

REFERENCES

Adams, P., E. Merwin and M. Mogavero. 1952. Flavor components of raspberries. Food Tech. 6:285.

Badings, H.T., de Jong, C., and Dooper, R.P.M. 1985. Automatic system for rapid analysis of volatile compounds by purge-and-cold-trapping/capillary gas chromatography. J. High Res. Chrom. and Chrom. Commun. 8:755.

Borejsza-Wysocki, W., Goers, S.K., McArdle, R.N., and Hrazdina, G. 1992. (p-hydroxyphenyl)butan-2-one levels in raspberries determined by chromatographic and organoleptic methods. J. Agr. Food Chem. 40:1176.

Braun, G. and E. Heike. 1977. Zur analyse von aromastoffen in lebensmitteln III. Mitteilung: Zurkenntnis der naturlichen gehalte an 1-(4'Hydroxyphenyl)-butanon-3(sog. Himbeerketon) in himbeeren und daraus hergestellten lebensmitteln und zum nachweis der kunstlichen aromatisierung mit 1-(4'-hydroxiphenyl)-butanon-3. Dtsch Lebensmittel-Rdsch 73:273.

Hokanen, E., *et al.* 1980. The aroma of Finnish wild raspberries, *Rubus idaeus* L. Z. Lebensm. Unters. Forsch. 112:180-182.

Larsen, M. and L. Poll 1990. Odour thresholds of some important compounds in raspberries. Z. Lebensm. Unters. Forsch. 191:129-131.

Latrasse, A. 1982. Qualite aromatique de la framboise (Rubus idaeus L.) II. Interpretation de l'indice d'arome. Lebensm.-Wiss. u.-Technol. 15:49.

Mattheis, J.P., Buchanan, D.A., and Fellman, J.K. 1991. Change in apple fruit volatiles after storage in atmospheres inducing anaerobic metabolism. J. Agr. Food Chem. 39:1602.

Shamaila, M., B. Skura, H. Daubeny, and A. Anderson 1993. Sensory, chemical and gas chromatographic evaluation of five raspberry cultivars. Food Res. Int. 26:443-449.

CURRENT AND PENDING SUPPORT

Instructions:

1. Record information for active and pending projects.
2. All current research to which principal investigator(s) and other senior personnel 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 P1 #1 first)	Supporting Agency and Project Number	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
Fellman, J. K.	Northwest Center for Small Fruits Research	10,975	1997-1998	5	Flavor components of Red Raspberries
	Pending:				
Fellman, J.K.	Washington State Tree Fruit Research Commission	17,000	1995-1998	10	Flavor Biochemistry of Apples
Fellman, J.K.	Washington Red Raspberry Commission	5,200	1998-2000	5	This Proposal

Project No.: New

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

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

Submitted by: Chaim Kempler and Hugh Daubeny
Agriculture and Agri-Food Canada, Pacific Agriculture Research Centre (Agassiz)
P.O. Box 1000, Agassiz, B.C., V0M 1A0.
Tel.: 604-796-2221 ext 224, Fax: 604-796-0359, Internet: KemplerC@em.agr.ca

Justification

The Pacific North West area is the leading producer of raspberries for the processing market. The Agriculture and Agri-Food Canada breeding programs support this industries and produce varieties that enhance production. Meeker is the leading cultivar that is grown for the processing market. It is suitable for machine harvesting and has dark fruit colour but is very susceptible to winter damage, and raspberry bushy dwarf virus (RBDV). Of particular importance is to fasten the release of cultivars that can replace Meeker with cultivars that are winter hardy and have disease and pest resistance as chemical control measure are no longer available.

Objectives

To test advance red raspberry selections stressing suitability for machine harvesting, dark fruit, winter hardiness, and resistance to root rot, divergent aphid biotype, and RBDV.

Primary

- Winter hardiness 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 qualities, which include flavour, size, firmness, ease of harvest, and rot resistance.
- Processing fruit needs to be dark, have high acid and soluble solids content.
- Resistance to pollen infection from the raspberry bushy dwarf virus (RBDV).

Secondary

- Resistance or tolerance to root rot (*Phytophthora fragariae)*, and lesion nematodes.
- Resistance or tolerance to cane diseases, like spur blight, cane *botrytis* and cane spot, spider mite, bacterial blight and crown gall.
- Resistance to leaf diseases such as rust, powdery mildew.
- Adequate replacement cane production.

Impacts and benefits:

The results of the evaluations will be directly available to the red raspberry industry and will determine which selections are most suitable for processing and machine harvest. The evaluations will help in determine if selections like BC86-6-15, BC89-6-12, BC89-32-69, BC90-1-42, BC90-2-45, BC90-4-23, BC90-4-48, BC90-5-26, BC90-11-44 and others are commercially suitable and can replace Meeker.

Activities

- Establish advance replicated cultivars trial to assess advance selection suitable for processing and machine harvest.
- Evaluation and propagation of advanced selections.
- Giving cultivar status to one or more of the selections.
- Supervise distribution of advanced selections to propagators and growers and subsequently monitor the performance of each.

Funding

While the total cost of red raspberry cultivar development should be about $ 154,500 over three years ($ 51,500 per year), we are asking WRRC's share for each year to be $ 8,000. The WRRC contribution will be matched by Agriculture and Agri-Food Canada Matching Initiative Funding (MII) with $ 8,000. This proposal will be also submitted to the B.C. Raspbery Growers Association and the Oregon Raspberry & Blackberry Commission.

Resource commitments (for each year between April 1998- March 2001):

Research assistance during April 1- Nov. 30,	$ 18,200
Summer students (3x$7,500)	$ 22,500
Land preparation (fertilizer, field fumigation, etc.)	$ 5,000
O&M (drip irrigation, trellis, etc.)	$ 4,800
Travel	$ 1,000
Total	**$ 51,500**

Collaborative partners:

Lower Mainland Horticultural Improvement Association (BC)
B.C. Raspberry Growers Association
Washington State Red Raspberry Commission
Oregon Raspberry & Blackberry Commission

Project No:
Title: Transmission of RBDV in the field
Year Initiated 1996 Current Year 1998 Terminating Year 1999

Personnel: Robert R. Martin and Suzannah Taylor, 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

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.

A survey was undertaken during the summer of 1996. We collected samples, 72 per field, from commercial fields contracted to fruit processors in Oregon, Washington and British Columbia. In the Fraser Valley (Whatcom Co. in Washington and Fraser Valley of B.C.) RBDV was widespread (25/28 fields had RBDV with 20 of these fields having over 50% infection rate). There was no TSV or TomRSV detected in samples from the Fraser Valley. In the Skagit Valley (south of the Fraser Valley but North of Everett, WA) RBDV was found in 1 of 6 fields, while TSV and TomRSV were not detected. In Southern Washington and Oregon TSV, TomRSV and RBDV were all found sporadically, with few fields having high levels of infection while most fields had little or no detectable virus. In this area RBDV, TSV and TomRSV occurred in 7/49, 8/49 and 10/49 fields, respectively. RBDV was not detected in the variety Willamette which is immune to the type strain but sensitive to newer strains detected in Europe over the last 10 years, suggesting that we do not have the resistant breaking strain in commercial fields.

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).

Objectives:

1. Determine if wild Rubus can serve as a RBDV inoculum source for Meeker raspberry (Thimbleberry is infected but its role as a source of RBDV in commercial fields is unclear).
2. Test hypothesis that thrips or some other flower visiting insects are involved in transmission of RBDV.
3. Test viability of raspberry pollen from RBDV infected and healthy raspberries to determine if RBDV alters viability. This could be a factor that may explain differences in rate of RBDV transmission between Northern Washington and Southern Washington.

This year we will be working on all three objectives.

Procedures:

Test native Rubus in Whatcom Co and B.C. for RBDV infection. Efforts will concentrate on Thimbleberry since we know that this plant is naturally infected at about 20% rate. We will also test other native Rubus including Salmonberry and trailing blackberry. From previous work (in the 1980's) we know that Thimbleberry is a carrier of RBDV but have little information on Salmonberry or the trailing blackberry near growers fields.

Pollen will be collected from RBDV infected and healthy native Rubus and Meeker plants. The pollen will be used in thrips transmission studies. Young plants will be dusted with infected or healthy pollen from both sources with or without the addition of thrips. We will also use pollen from each source to pollinate healthy Meeker plants.

Anticipated Benefits and Information Transfer:

Understanding how RBDV is transmitted in the field should provide information necessary to develop strategies to control this virus in the field. If thrips are involved in the movement of the virus from plant to plant than it should be possible to control thrips during the bloom period to minimize their transmission of RBDV.

Results will be made available to the growers via presentations at growers meetings and viewing of field plots as they are available.

Budget:

Request for 1998	4,000
Salaries	3,000
Travel	1,000

These funds will help support a student working on this project.

Project No:

Title: Engineering resistance to tomato ringspot virus

Year Initiated **1997** **Current Year 1998** **Terminating Year** 2001

Personnel: Robert R. Martin, Karen Keller and Paul Kohnen, 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 & Rick Bestwick, Agritope Inc., Beaverton, OR.

Justification:

Tomato ringspot virus is a nematode transmitted virus that is controlled by soil fumigation and or fallowing soil combined with the use of cover crops that are nonhost for the virus. None of these techniques will completely eliminate the virus carrying nematode from the soil. At best we can reduce the number of nematodes and the virus concentration to the point where it should be economically feasible to replant raspberries. Recent work in New York with transgenic tobacco shows that use of the coat protein of tomato ringspot virus as a transgene will provide resistance to this virus. If we can develop resistance to this virus in raspberry, than the need for soil fumigation to control *Xiphinema americanum* should not be necessary since it is rare that this nematode reaches populations that it is doing damage to plants. Having resistant plants will increase the longevity of raspberry fields in areas where tomato ringspot virus is a problem. This virus is known to occur in the Willamette Valley in Oregon as well as on the west side of the Cascades in Washington as far north as Bellingham. Tomato ringspot virus is rare in the Fraser Valley which is likely due to the presence of a different nematode in that area of the Pacific Northwest, *Xiphinema bakeri*.

The group at Agritope Inc. has developed an efficient procedure for transformation of raspberry. In the interest of getting this project to field trials in as little time as possible with varieties of interest to the industry this project is a collaborative effort with Agritope to bring the expertise of the two groups together. The transformation process will be the same as that used in a related project that we are developing to engineer resistance to raspberry bushy dwarf virus, but we will be working with a different set of genes in this project.

Objectives:

1. Clone and sequence the coat protein of tomato ringspot virus (1998).
2. Carry out mutagenesis of the coat protein of tomato ringspot virus so that we can transform with a nontranslatable RNA (cosuppression typ of resistance) (1998).
3. Transform raspberry with constructs developed (1998).
4. Challenge transgenic plants with tomato ringspot virus by grafting in the greenhouse (late 1998 and early 1999).
5. Set up field trials with the transgenic plants at sites with high levels of *Xiphinema americanum* and a history of tomato ringspot virus (1999).

This year we will be addressing objectives 1,2,3 and beginning on 4. We plan to put in field trials with these transgenic raspberries in the spring of 1999.

Procedures:

This project requires a significant amount of tissue culture materials for plant propagation and regeneration, and laboratory supplies (enzymes, RNA and DNA extraction kits, and various detection assays for analysis of transgenic plants. The coat protein gene of an isolate of tomato ringspot virus from raspberry in the Pacific Northwest will be cloned and sequenced. Site directed mutagensis will be used to add an initiation site to the coat protein gene that we wish to have expressed in plants. Two stop codons will be added to the beginnning of the coat protein gene construct that we want as nontranslatable RNA. (The stop codons will prevent the coat protein from being made from this construct and allow us to have the viral RNA in the plant but not any viral proteins).

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 Tomato ringspot virus. 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. Methods to detect DNA, RNA and proteins will be used to ensure the gene is inserted and to ensure that the gene is functional in raspberry plants.

Anticipated Benefits and Information Transfer:

Resistance to tomato ringspot virus in raspberry will increase the life of raspberry plantings by eliminating the decline, crumbly fruit symptoms 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.

Results will be made available to the growers via presentations at growers meetings and viewing of field plots as they are available.

Budget:

Request for 1998	8,000
Salaries	7,000
Supplies	1,000

Project No:

Title: Engineering resistance to raspberry bushy dwarf virus

Year Initiated 1995 Current Year 1998 Terminating Year 2000

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 & Rick Bestwick, 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).

After considerable effort at developing a regeneration (growing raspberry plants from leaf pieces) method for rasbperry cultivars grown in the Pacific Northwest we have met with relatively little success. In the mean time the folks at Agritope of Beaverton, OR have been able to transfrom raspberry including the variety Meeker. Therefore, we have setup a cooperative agreement 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. We therefore have cloned and sequenced the movement protein of RBDV as well as designed mutants of this gene. Together with Agritope Inc. these genes are being transfromed into 'Meeker' raspberry.

This project is of importance in Oregon and British Columbia as well as it is to Washington. RBDV is much more prevalent in Northern

Washington and B.C. than it is in Oregon, however it does occur 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, continue in 1998).
6. Test transgenic plants for virus resistance in the greenhouse (start in 1998).
7. Test transgenic plants in field trials for virus resistance and fruit quality (Set up first field trials in 1998).

This year we will be addressing objectives 5 and 6, we plan to put in field trials with the first sets of transgenic raspberries in the spring of 1998.

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). The virus coat protein is cloned, sequenced and transferred to Agrobacterium for transformation experiments. Methods to detect DNA, RNA and proteins will be used to ensure the gene is inserted and to ensure that the gene is functional in raspberry plants.

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.

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 1997	10,000
Request for 1998	10,000
Salaries	7,000
Supplies	3,000

See accompanying progress report for more details of what was accomplished in 1997.

Proposal to the Washington Red Raspberry Commission 1998-99

Title: Nitrogen use in 'Meeker' red raspberry and its impact on fungal cane and fruit diseases

Year Initiated: 1998 **Current Year:** 1998-99 **Terminating Year:** 1999-2000

Principal Investigators: Bernadine Strik, Professor, Horticulture, Berry Production System Research Leader, NWREC, Oregon State University (OSU)

Pete Bristow, Associate Plant Pathologist, Washington State University

Cooperators: Bernie Zebarth, Soil Scientist, Agriculture Canada
Tim Righetti, Professor, Horticulture, OSU
John Hart, Extension Soil Scientist, OSU

Justification:

The Pacific Northwest is the leading red raspberry production region in North America. However, very little fertility work has been done on this crop in our region. "How much nitrogen do red raspberries need and when should I apply it", is a relatively common industry question. Growers themselves are experimenting; however, little, if any, controlled experiments have been done. One of the problems with N fertilization studies is that our soils, in general, are quite fertile; often this results in delayed effects of treatments in fertility studies (i.e. it may take a while for an unfertilized control to show a reduced yield). Using labeled nitrogen (a safe isotope that can be traced in the plant) avoids this problem. Even if a plant takes up a small amount of labeled nitrogen, it can be traced. This allows one to determine when the plant takes up nitrogen and where it goes -- an essential piece of information necessary to establish fertility recommendations.

Industry practices of N fertilization vary both in rates and timing. Although the red raspberry industry in Oregon has not been directly implicated in nitrate contamination of ground water, over application of nitrogen can lead to problems -- in a survey of 21 red raspberry fields in British Columbia, soil nitrate-N levels in October were as high as 310 lb per acre (Chipperfield, 1992); this nitrate is washed out of the root zone in fall and winter. In this study, we will collect the information red raspberry growers need to prepare themselves for questions regarding potential of ground water contamination. Optimization of N application based on use efficiency and soil mineralization would not only save growers money and optimize plant growth, but could also reduce the risk of ground water contamination through over-application of N and leaching past the root zone.

Spur blight causes losses in yield on extremely vigorous plantings especially when excessive nitrogen has been applied. Any practice, which promotes the rapid filling in of the plant canopy and lengthens the drying time of leaves and canes after overhead irrigation and/or rainfall favors the development of the spur blight disease. These same conditions also promote several fungal fruit rots (primarily *Botrytis*) as well as cane botrytis and cane blight (*Leptosphaeria coniothyrium*). Cane blight is usually only troublesome in machine harvested field because harvester wounds on primocanes provide entry points for this wound parasite.

In wet Springs the spur blight pathogen can attack the fruiting laterals. Pedicels and the lateral itself can be girdled. Also a leaf spot can develop which leads to premature death of the very leaves that are suppose to be producing carbohydrates to fill developing berries. This type of damage was common in Whatcom County in 1997. In short, spur blight was as much a leaf disease as it was a cane disease. Damage from the cane phase will reduce the 1998 crop.

Objectives:

- Study the effects of nitrogen (N) fertilization rate and timing on N uptake and partitioning in red raspberry
- Determine the amount and timing of soil mineralization of N that occurs in a mature red raspberry field
- Assess the impact of nitrogen use on cane and berry diseases caused by fungi. (Primary focus will be spur blight and Botrytis fruit rot but treatments will also be evaluated for cane botrytis and cane blight, if present).

Procedures:

This will be a two-year study in a mature red raspberry 'Meeker' field at the North Willamette Research and Extension Center (NWREC). The field is 1/3 of an acre in size with individual plots being 20' (8 plants) long with a 10' space after each to allow for clearing of fruit from the machine between plots. Treatments will be replicated 4 times.

Crop uptake and distribution of nitrogen. To address the first objective we will use the following treatments to monitor the movement of N in a raspberry plant and how N reserves (if any) are remobilized the following year.

Treatments: **A.** No added nitrogen (N -- control); **B.** N applied at a full rate of 80 lb per acre just after bud break (^{15}N depleted fertilizer); **C.** N applied at a rate of 40 lb per acre just after bud break (^{15}N depleted); **D.** N applied at a rate of 80 lb per acre split with half at bud break (not depleted) and half in late May at early fruit set (^{15}N depleted).

^{15}N-depleted ammonium nitrate fertilizer (33% N) will be used in order to be able to monitor when N uptake occurs and where it's partitioned in the plant. The ^{15}N depleted fertilizer will be applied to treatments B, C, and D as indicated in 1998. Only non-depleted N (normal fertilizer) will be applied the second year, 1999, so redistribution of the ^{15}N applied in 1998 can be measured. The presence of any residual ^{15}N remaining in the soil will be determined by using indicator plants (established in the field and analyzed for ^{15}N).

Plants will be destructively sampled throughout 1998 and 1999. Four single plant replicates in each year will be excavated on each of 3 dates: one month after application of spring ^{15}N (April), fruit maturity (July), and training time (October). On each of these sample dates, plants will be partitioned into crown, primocanes, primocane leaves, floricanes, floricane leaves, fruit laterals, and fruit (if present); dried to a constant dry weight and analyzed for amount of total N and ^{15}N present. On additional dates of: fruit filling period (June) and post-harvest (August), primocanes and floricanes will be sub-sampled from the plot, separated into primocanes, primocane leaves, floricanes, floricane leaves, fruit laterals, and fruit (if present); dried to a constant dry weight; and analyzed for amount of total N and ^{15}N present.

Yield data will be collected on fruiting plants using machine harvest. Fruit will be sub-sampled for berry weight. A sub-sample of fruit will also be collected just prior to first harvest to assess fruit firmness. Primocanes and floricanes will be subsampled in plots to assess percent bud break, fruiting lateral length and the number of fruiting sites per lateral.

Soil mineralization of nitrogen. There is very little presently known with respect to how much soil N is supplied to the crop, how much is mineralized in the soil, and when this occurs relative to the time of crop N uptake. All of this information is necessary when establishing N fertility recommendations.

This study will be done in conjunction with the previous experiment. All of the above mentioned treatments will be studied with the addition of a bare soil "treatment" (no raspberry plants).

Before fertilizer application in March 1998 (and 1999), the amount of available N present in the soil will be established as a "baseline". At each of the above mentioned plant sampling dates, soil samples will be taken to determine available N content and thus mineralization. Soil samples will be collected at depths of 0-15, 15-30, and 30-60 cm in each rep/treatment plot. This would indicate the increase in crop and soil inorganic N between sampling dates.

Cane diseases: The incidence and severity of spur blight will be determined on leaves of fruiting laterals and on leaves of primocanes during the Summer 1998. In Fall 1998 the incidence and location of cane lesions on overwintering canes will be determined. The cane lesion data will be compared with bud break data collected in Spring 1999. If cane botrytis is present it will be evaluated in Fall 1998. In Spring 1999 the overwintering canes will be examined for evidence of cane blight.

Fruit diseases: On two harvest dates in Summer 1998 ripe berries will be harvested by hand and evaluated for fruit rot (primarily *Botrytis* but also *Rhizopus* and *Cladosporium*) in post harvest storage tests.

The plan is to collect the same data during the second year of the study. The final data will be collected in Spring 2000 (bud survival and cane blight evaluations).

Anticipated Benefits and Information Transfer:

After this two-year study, we will know when 'Meeker' takes up N, how N is partitioned in the plant, how much is remobilized from stored reserves in the spring and how soil mineralization of nitrogen should impact crop fertilization. We will know whether a single application of N or a split application is more efficient and what rate of N may be appropriate. These findings should provide very useful information to growers in the Pacific Northwest on N fertilization practices in red raspberry. We will also know whether N fertilization rate and timing impact fruit rot and cane disease.

Results will be disseminated to industry the first year through presentations, field day discussions and newsletter articles.

Budget:

First year expenses (WARRC is being asked to support part of total cost -- see attached)

	Pete Bristow, WSU	Bernadine Strik, OSU
Temporary labor ($10/hour)	$1125	$2400
Transportation (Motor pool)	$ 475	-0-
Supplies & Services	$ 275	$ 600
TOTAL	$1875	$3000

Current & Pending Support

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

Name (List PI #1 first)	Supporting Agency and Project #	Total $ Amount	Effective and Expiration Dates	% of Time Committed	Title of Project
	Current:				
	Pending:				
Strik	NCSFR	$11,739	3/98-4/99		Nitrogen use and management in red raspberry
Strik and Bristow	ORBC	$ 5,496	7/98-6/99		Nitrogen use in 'Meeker' and impact on cane disease

A:instruct.98/cp2/cm
10/97

Project No: New

Title: Caneburning in Red Raspberries

Year Initiated: 1998 **Current Year:** 1998 **Terminating Year:** 1999

Personnel: Timothy W. Miller, Extension Weed Scientist, WSU--Mt. Vernon
Carl R. Libbey, Ag. Research Technologist, WSU--Mt. Vernon

Justification:

Herbicides have been widely used for years to suppress raspberry primocane growth in the spring. Caneburning was initially conducted to aid in the mechanical harvest of berries, but an enhanced level of weed control within the crop row was often 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.

Objectives:

1. Conduct advanced testing of primocane suppression products at various rates and in tank mixtures, evaluating them by their efficacy and crop safety.

2. Screen new herbicides for primocane suppression potential, weed control, and crop safety in red raspberry.

Procedures:

1. Caneburning studies will be conducted on grower raspberry fields. Products of interest are Goal (oxyfluorfen) and Enquik (monocarbamide dihydrogensulfate) , and advanced test products glufosinate and carfentrazone (several potential trade names, but none yet selected by the companies). Goal and Enquik have Washington Special Local Needs labels; glufosinate and carfentrazone have been entered into residue testing in the federal IR-4 program. 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 compared to the Goal application (industry standard).

2. Caneburning studies with new compounds will be conducted on grower raspberry fields. New products of interest are Basagran (bentazon), Buctril (bromoxynil), Betanex (desmedipham), Spin-Aid (phenmedipham), Prefar (bensulide), and Tough (pyridate). These products meet the criteria discussed in the **Justification** section (i.e., they are primarily contact herbicides with little if any translocation into root systems, display short soil residuals, are not taken up by roots, and are not volatile under typical environmental conditions at the time of application). 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 compared to a Goal application (industry standard).

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 1998
Time-slip	$ 5,000
Operations (goods & services)	1,000
Travel	
Projected Needs	250
Meetings	0
Other	0
Equipment	0
Employee Benefits (16%)	750
Total Request	$ 7,000

Other Support of Project:

Herbicides are typically provided by herbicide manufacturers. Additional funding for the use of glufosinate and carfentrazone to control primocane growth in red raspberries will be requested from the Washington State Commission on Pesticide Registration and an equal amount from the manufacturers of those herbicides.