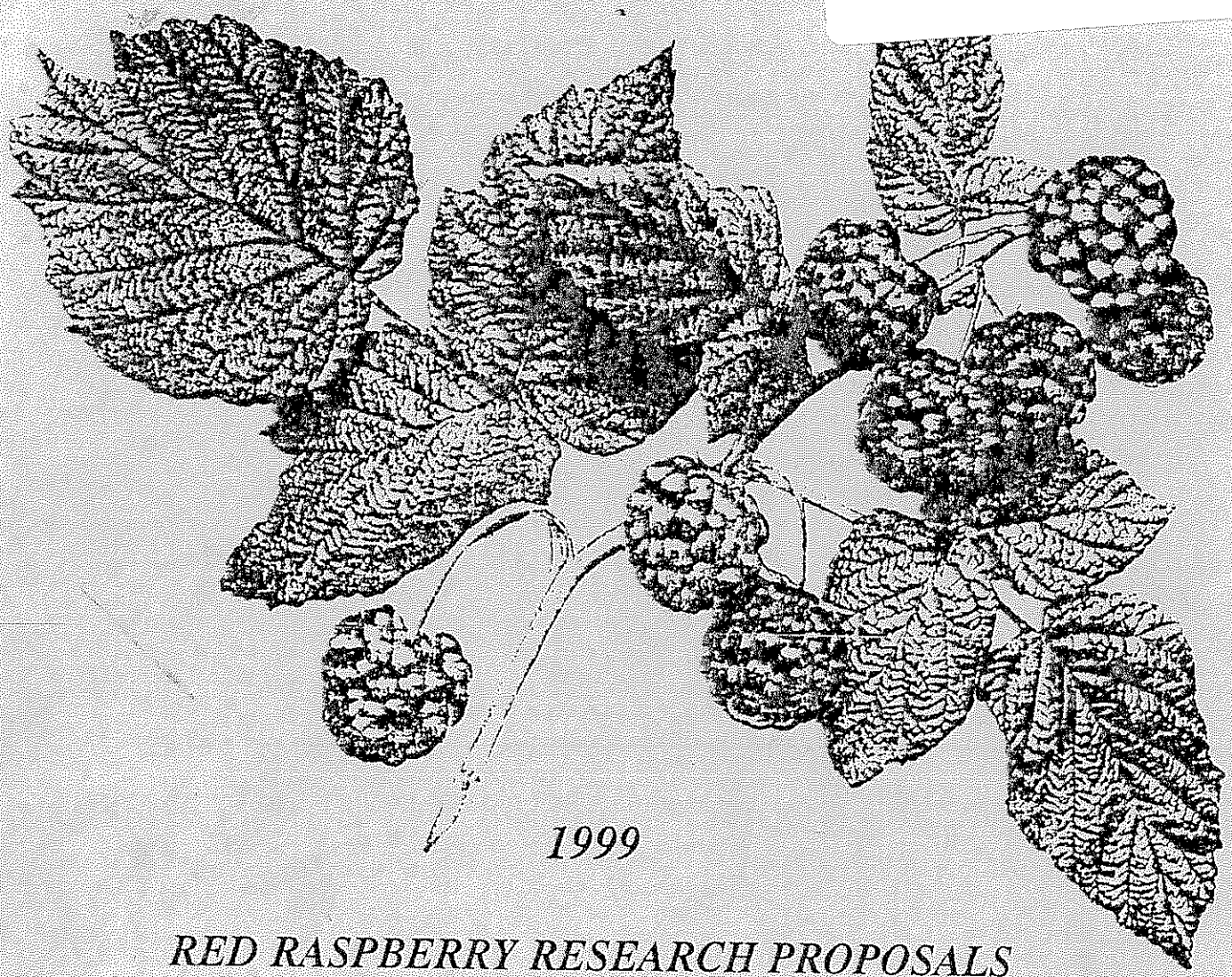
RS



*1999*

# *RED RASPBERRY RESEARCH PROPOSALS*

## *1998 PROGRESS REPORTS*

*to the*

*WASHINGTON STATE RED RASPBERRY COMMISSION*

*and*

*NORTHWEST RED RASPBERRY GROWERS ASSOCIATION*

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A:RaspComm.98/cp3/cm
11/98

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## *Summary*
## *Budget Requests*

### *On-Going Projects*

| Project No. | Short Title | Lead Scientist | Amount Requested |
|---|---|---|---|
| 13C-3755-5641 | Raspberry Breeding | Moore | $ 32,000 |
| 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 | 36,500 |
| 13C-3543-6967 | Twospotted Spider Mite Resist. | Tanigoshi | 3,780 |
| 13J-3543-4977 | Orange Tortrix Control | Tanigoshi | $ 2,320 |
| 13C-3555-5784 | Yield Efficiency | Klauer | 10,500 |
| 13C-3761-7784 | Resistance to Root Rot | Bristow | 3,875 |
| 13C-3761-6718 | Control of Phytophthora | Bristow | 3,985 |

### *New Projects*

| Short Title | Lead Scientist | Amount Requested |
|---|---|---|
| Bushy Dwarf Resistance | Martin | 10,000 |
| Cultivar Development for PNW | Kempler | 5,000 |
| Caneburning & Weed Control | Miller | 14,600 |
| Gypsum to control Root Rot | Bristow | 2,450 |
| Field Evaluation of new Fungicides | Bristow | 7,400 |

A:Raspbk.99/cp3/cm

**Project:** 13C-3755-5641
**Title:** Red Raspberry Breeding, Genetics and Clone Evaluation
**Personnel:** Patrick P. Moore, Associate Horticulturist,
WSU Puyallup Research and Extension Center
**Reporting Period:** 1998

**Accomplishments:** In 1998, 87 crosses were made for cultivar development. Four additional crosses were made between 'Meeker' and 'Tulameen' and *Rubus* species. About 2,700 seedlings were planted at Puyallup from 1997 crosses. Selections will be made among these seedlings in 2000 and 2001. A new replicated planting was established with 74 clones on raised beds treated with gypsum and Ridomil. Sixty-one selections were made from seedlings planted in 1995 and 1996, 55 for cultivar development and 6 for breeding purposes. Cherokee, Tulameen, WSU 1020, WSU 1068 WSU 988 and WSU 1069 were the best parents.

The 1995 replicated planting was harvested for the second time in 1998 (Table 1). It was planted in an area with high levels of root rot, which resulted in missing plots and high variability. Only five clones had all three plots alive in 1998. Meeker was the only cultivar that had all three plots survive. WSU 1145 was very vigorous and healthy, but the yields were only slightly above the planting average. WSU 1139 and WSU 1121 had low yields in 1997, but performed well in 1998. Both had two of the four plots completely die out from root rot and some plants in the surviving plots died as well.

The 1996 replicated planting established on raised beds was harvested for the first time in 1998 (Table 2). Selections that have been distributed to growers for trial had the highest yields. GEL-20 had high yields in two plots, but had a plot die from root rot even on raised beds. WSU 1068 was represented by only 2 plots, as result of lack of planting material, not from plots dying.

Fruit was frozen of 13 clones for evaluation as juice, puree, and IQF fruit. The fruit samples will be evaluated in a tasting winter 1998-99. Eleven selections (WSU 1024, WSU 1035, 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. WSU 1112 is being propagated for grower trial, and WSU 1145 is being propagated for further evaluation.

**Publications:**

Moore, P.P. 1998. Variation in Drupelet Number and Size in Pacific Northwest Red Raspberries Fruit Var. J. 52:103-106.

Moore, P. P. and D. D. Trople. Crossibility of *Rubus* Species in the WSU Breeding Program. Acta Hort. (Accepted for Publication).

Trople, D. D and P. P. Moore. Taxonomic Relationships in *Rubus* based on RAPD Analysis. Acta Hort. (Accepted for Publication).

**Presentations:**

January, 1998. Strawberry and Raspberry fruit display. Northwest Food Processors, Portland, OR.

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

July, 1998. Small Fruit Open House, Mt. Vernon, WA.

Table 1. 1997-98 harvest of 1995 planted raspberries, Puyallup, WA.

| | Yield (t/a) | | | Fruit | Fruit | Fruit | Harvest Season | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1998 | 1997 | Total | Weight (g) | Rot (%) | Firmness (g) | 5% | 50% | 95% | Length of season |
| Clones Represented by 3 replications. | | | | | | | | | | |
| Meeker | 8.9 A | 9.3 A | 18.2 A | 4.0 A B | 0.4 B | 201 B | 7/4 A | 7/14 A | 7/25 A | 21 A |
| **WSU 1068** | 9.2 A | 5.7 B | 14.9 A B | 3.9 A B | 1.6 A | 162 C D | 6/19 B | 6/30 B | 7/15 B | 26 A |
| WSU 1145 | 7.1 A B | 6.4 B | 13.5 B | 4.5 A | 0.5 B | 186 B C | 7/3 A | 7/13 A | 7/29 A | 26 A |
| **WSU 1067** | 6.9 A B | 5.6 B | 12.6 B | 4.1 A B | 1.8 A | 146 D | 7/1 A | 7/10 A | 7/23 AB | 23 A |
| WSU 1137 | 4.9 B | 5.4 B | 10.3 B | 3.7 B | 0.4 B | 253 A | 6/30 A | 7/11 A | 7/27 A | 27 A |
| Clones Represented by 2 replications. | | | | | | | | | | |
| WSU 1139 | 14.0 A | 6.6 A B | 20.5 A | 4.7 B | 0.5 C D | 183 B - D | 6/26 A - C | 7/6 B C | 7/17 A - D | 21 B - D |
| WSU 1121 | 11.2 A B | 7.8 A | 19.0 A | 4.2 B C | 1.6 B C | 211 B | 6/22 B - D | 7/4 C | 7/22 A - C | 29.5 A |
| WSU 1128 | 9.3 A - C | 6.7 A B | 15.9 A B | 3.7 B - D | 1.0 B - D | 144 C D | 6/28 A B | 7/11 A B | 7/24 A | 26.5 A B |
| **WSU 1066** | 7.6 A - C | 6.2 A B | 13.8 A B | 6.1 A | 3.9 A | 184 B - D | 6/22 C D | 7/5 C | 7/16 B - D | 24 A - C |
| WSU 1132 | 5.7 A - C | 7.6 A | 13.3 A B | 4.4 B C | 0.8 B - D | 270 A | 6/30 A | 7/12 A | 7/23 A B | 23 A - C |
| WSU 1122 | 6.1 A - C | 6.4 A B | 12.4 A B | 2.7 D | 0.9 B - D | 164 B - D | 6/25 A - D | 7/6 B C | 7/19 A - D | 24.5 A - C |
| Willamette | 7.6 A - C | 4.3 B | 11.9 A B | 3.5 B - D | 0.1 D | 192 B C | 6/25 A - D | 7/4 C | 7/17 A - D | 22.5 A - C |
| WSU 1138 | 5.4 B C | 6.5 A B | 11.8 A B | 2.7 D | 0.3 D | 127 D | 6/24 B - D | 7/4 C | 7/16 B - D | 22.5 A - C |
| WSU 1136 | 3.0 B C | 6.6 A B | 9.6 B | 2.8 D | 0.2 D | 127 D | 6/25 A - D | 7/3 C | 7/14 C D | 19 C D |
| WSU 1140 | 2.5 C | 7.0 A B | 9.4 B | 2.9 D | 0.5 C D | 184 B - D | | | | |
| WSU 1134 | 3.2 B C | 6.0 A B | 9.1 B | 3.0 D | 0.4 C D | 168 B - D | 6/21 C D | 6/28 D | 7/14 D | 23 A - C |
| WSU 1127 | 3.5 B C | 4.9 A B | 8.4 B | 3.3 C D | 1.9 B | 133 C D | 6/20 D | 6/24 D | 7/5 E | 15 D |
| Average | 6.8 | 6.4 | 13.2 | 3.8 | 1.0 | 178 | 6/26 | 7/6 | 7/19 | 23 |

Means within a column followed by the same letter are not significantly different using Duncan's Multiple Range Test, P=0.05.
Clones indicated by bold print have been distributed to growers for grower trial.

Table 2. 1998 harvest of 1996 planted raspberries, Puyallup, WA

| | Yield (t/a) | Fruit Weight (g) | Fruit Rot (%) | Fruit Firmness (g) | Harvest Season 5% | 50% | 95% | Length of season |
|---|---|---|---|---|---|---|---|---|
| **Clones Represented by 3 replications** | | | | | | | | |
| **WSU 1067** | 11.5 A | 4.3 B | 1.8 B C | 127 G H | 7/4 A - D | 7/13 A - D | 7/28 A - D | 24 B - E |
| WSU 1162 | 10.7 A B | 3.7 B - F | 2.1 A - C | 150 E - G | 7/4 A - D | 7/15 A | 7/31 A | 27 A - C |
| **WSU 1024** | 10.5 A - C | 4.1 B - E | 0.4 C | 198 B | 7/6 A | 7/15 A | 7/30 A B | 24 B - E |
| **WSU 1082** | 9.9 A - D | 5.2 A | 4.4 A | 179 B - E | 6/30 D - H | 7/10 D - F | 7/21 E - G | 21 C - H |
| **WSU 1098** | 9.5 A - D | 3.5 B - F | 0.6 B C | 76 J | 7/3 A - D | 7/11 B - F | 7/22 D - G | 19 E - H |
| Tulameen | 8.7 A - E | 4.2 B C | 0.4 C | 159 D - G | 7/2 A - D | 7/11 B - F | 7/25 B - F | 23 B - F |
| WSU 1164 | 8.7 A - E | 3.8 B - F | 0.8 B C | 109 H I | 7/4 A - D | 7/12 A - F | 7/24 D - G | 20 E - H |
| Comox | 8.5 A - E | 3.6 B - F | 1.6 B C | 195 B C | 6/27 F - H | 7/9 E F | 7/20 F G | 23 B - G |
| **WSU 1096** | 8.4 A - E | 3.4 D - G | 3.2 A B | 141 F - H | 6/28 E - H | 7/11 B - F | 7/27 A - D | 30 A |
| **WSU 1066** | 8.2 A - E | 3.5 B - F | 0.7 B C | 142 F - H | 7/1 C - F | 7/10 D - F | 7/25 B - F | 24 B - E |
| **WSU 1099** | 8.1 A - E | 3.6 B - F | 0.4 C | 137 F - H | 6/30 D - G | 7/11 B - F | 7/25 B - G | 24 B - E |
| WSU 1153 | 8.0 A - E | 3.4 E - G | 0.7 B C | 163 C - F | 7/2 B - E | 7/11 B - F | 7/23 D - G | 22 C - H |
| WSU 1159 | 7.9 A - E | 2.4 I | 0.9 B C | 111 H | 6/26 H | 7/9 F | 7/22 D - G | 26 A - D |
| Meeker | 7.8 A - F | 3.3 F G | 0.4 C | 165 B - F | 7/2 B - E | 7/14 A - C | 7/29 A - C | 28 A B |
| WSU 1156 | 7.6 A - F | 4.1 B - D | 1.4 B C | 170 B - F | 7/2 A - D | 7/13 A - E | 7/24 C - G | 22 C - H |
| Willamette | 7.2 A - F | 3.1 F - H | 0.3 C | 155 D - G | 6/27 G H | 7/9 F | 7/22 E - G | 25 A - E |
| WSU 1166 | 6.4 B - F | 2.6 H I | 1.5 B C | 80 I J | 6/27 F - H | 7/10 D - F | 7/21 E - G | 23 B - E |
| WSU 1152 | 6.3 C - F | 3.5 C - F | 0.5 B C | 138 F - H | 7/3 A - D | 7/13 A - D | 7/25 B - F | 22 B - H |
| ORUS 2078 | 6.3 C - F | 3.6 B - F | 0.6 B C | 147 E - G | 7/5 A - C | 7/14 A B | 7/26 A - E | 21 D - H |
| WSU 1163 | 6.2 C - F | 3.0 F - I | 0.5 B C | 113 H | 7/2 A - D | 7/11 B - F | 7/23 D - G | 21 E - H |
| WSU 1155 | 5.9 D - F | 4.9 A | 1.1 B C | 233 A | 7/6 A B | 7/12 A - F | 7/23 D - G | 17 G H |
| WSU 1158 | 5.1 E F | 2.8 G - I | 0.4 C | 150 E - G | 7/4 A - D | 7/12 A - F | 7/21 E - G | 17 H |
| NY 7 | 3.6 F | 3.7 B - F | 0.3 C | 189 B - D | 7/2 B - E | 7/10 C - F | 7/19 G | 18 F - H |
| **Clones Represented by 2 replications** | | | | | | | | |
| **WSU 1068** | 11.1 A | 4.4 A | 2.0 A B | 161 C D | 6/21 E | 7/3 C | 7/17 C | 25.5 A - C |
| GEL-20 | 10.9 A B | 3.5 A B | 1.2 A - C | 149 C - E | 6/21 E | 7/4 C | 7/20 B C | 29.5 A |
| Malahat | 9.1 A B | 4.1 A B | 0.8 B C | 172 B C | 6/26 D | 7/8 B | 7/22 B C | 25.5 A - C |
| **WSU 1097** | 7.3 A B | 3.2 A B | 0.8 B C | 104 E | 6/28 D | 7/11 A B | 7/26 A B | 28.5 A |
| ORUS 958-10 | 5.2 A B | 2.9 A B | 0.1 C | 253 A | 7/7 A | 7/13 A | 7/25 A B | 17.5 D |
| KCB-1 | 4.7 A B | 2.6 B | 2.4 A | 123 D E | 7/2 C | 7/14 A | 7/21 B C | 19 C D |
| WSU 1157 | 4.6 A B | 4.1 A B | 0.3 C | 214 A B | 7/6 A B | 7/15 A | 7/28 A B | 21.5 B - D |
| WSU 1160 | 4.1 B | 3.5 A B | 0.7 C | 145 C - E | 7/4 B C | 7/14 A | 7/30 A | 26.5 A B |
| **Clone represented by a single plot** | | | | | | | | |
| BC 86-6-15 | 4.1 | 3.3 | 0.7 | 181 | 6/26 | 7/7 | 7/22 | 26 |
| Average | 7.6 | 3.6 | 1.1 | 154 | 7/1 | 7/11 | 7/24 | 23 |

Values represent means of 3 hill plots.
Means within a column followed by the same letter are not significantly different using Duncan's Multiple Range Test, P=0.05.
Clones indicated by **bold** print have been distributed to growers for grower trial.

**PROJECT:** 13C-3755-5641

**TITLE:** Red Raspberry Breeding, Genetics and Clone Evaluation

**YEAR INITIATED:**1999
**CURRENT YEAR:**1999
**TERMINATING YEAR:**2002

**PERSONNEL:** Patrick P. Moore, Associate Horticulturist,
WSU Puyallup Research and Extension Center, Puyallup, WA

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

There has been a history of cooperation between the breeding programs in Oregon, British Columbia, and Washington. Crossing plans for each of the programs are exchanged and compared. Seed, seedlings and selections are exchanged among the programs. This cooperation needs to continue. Cultivars developed by these programs will be of value to the entire PNW raspberry industry.

**OBJECTIVE:** Develop summer fruiting red raspberry cultivars with improved yields and fruit quality, and resistance to root rot and raspberry bushy dwarf virus (RBDV). Selections adapted to machine harvesting or fresh marketing will be identified and tested further.

**WORK PLAN:** This is an ongoing project which depends on continuity of effort. Each year new crosses will be made, new seedling plantings established, new selections made among previously established seedling plantings, and selections made in previous years evaluated.

1. Crosses will be made for summer fruiting cultivar development. Clones identified by ongoing disease and insect resistance, fruit color, and drupelet number studies will be used as parents. Other important traits included are

ease of fruit removal, fruit firmness, fruit size, fruit color, harvest season, fruit rot resistance, and growth form.

2. 87 crosses were made for cultivar development in 1998. 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 2001 and 2002.

3. Selections will be made among the seedlings planted in 1996 and 1997. Seedlings will be subjectively evaluated for yield, flavor, appearance, color, harvest season and growth form. Based on these observations, seedlings will be selected for propagation and further evaluation. Typically the best 1% or less of a seedling population will be selected.

4. Seedlings selected in 1998 (55 selections) will be propagated for testing in three replications of three hill plots and compared to standard cultivars. Six other selections made in 1998 will be used for breeding only. Because of the prevalence of root rot in the field and the subsequent difficulties in propagation by root cuttings, shoots of all selections will be collected and placed into tissue culture. Selections will be evaluated for yield, fruit size, fruit firmness, fruit rot, and harvest season as well as pest and disease resistance in 2001 and 2002. A fourth replication will be planted for subjective evaluations and use in pollinations.

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

6. The replicated planting established in 1996 will be harvested for the second time and the planting established in 1997 will be harvested for the first time in 1999.

7. Plants will be multiplied in tissue culture and propagated for testing at other locations and grower trials. WSU 1112 is currently being propagated and may be available for grower trial in 1999.

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

## ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

This program will develop new raspberry cultivars that are more productive or more pest resistant. Such cultivars may result from crosses made this year or may already be under evaluation. Selected seedlings will be rapidly propagated and tested as rapidly as possible. Promising selections will be tested by commercial growers and release decisions made as rapidly as possible. Research results will be communicated at grower meetings, commission meetings, and field days.

**PROPOSED BUDGET:** Support is requested for a portion of the project operations budget at WSU Puyallup. Salaries for one WSU faculty member, two support staff, and some operating funds (minus vehicle and phone charges) are provided by WSU for breeding work on BOTH strawberries and raspberries. This request provides for 0.25 of an Agricultural Research Technician I. The remaining 0.35 of the cost of the position will be funded for 1999-2000 by other commissions. The remaining funds in the request will be used for timeslip labor for harvest, data collection, tissue culture supplies, greenhouse supplies and travel to research plots and to grower meetings to present results of research.

| **Budget:** | **1998-99** | **1999-2000** |
|---|---|---|
| 00 Salaries | | |
| Agr. Res. Tech. 0.25 FTE | $7,690 | $8,305 |
| G.R.A. I 0.20 FTE | 4,116 | |
| 01 Timeslip Labor | 7,000 | 12,500 |
| 03 Service and Supplies | 4,166 | 5,539 |
| 04 Travel | 500 | 500 |
| 07 Benefits | | |
| Agr. Res. Tech. | 2,922 | 3,156 |
| G.R.A. I | 2,486 | |
| Timeslip | 1,120 | 2,000 |
| **Total** | **(Requested) $30,000** | **$32,000** |
| | **(Funded) $29,000** | |

## 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:<br>Oregon Raspberry and Blackberry Com. | $1,000 | 1998-99 | | 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:** 1998

**Accomplishments:**
A new planting of 17 clones was established at WSU Vancouver in 1996 on raised beds. In addition to standard cultivars, the planting included NY-7 a new cultivar from the breeding program at Cornell (released as Encore), ORUS 2078, ORUS 958-10, BC 86-6-15 and WSU selections.

In the 1998 proposal, plans were to harvest this planting in 1998 and 1999 and to establish a new planting. The proposal was only partially funded. The Chair of the Washington Red Raspberry Commission Research Committee was consulted about expectations with this level of funding. After discussion with the Chair of the Research Committee, the plots were maintained, but no harvest data was collected and a new planting was not established. In the 1996 planting, some plots of each clone suffered root rot damage even on the raised beds. Most plots retained vigor and useful data could be obtained by harvesting these plots in 1999 provided funding is adequate.

**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:** 1999
**TERMINATING YEAR:** 1999

**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.

**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:** 1999
**TERMINATING YEAR:** 1999

**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 1999.

2. A new replicated planting of raspberry clones will be established at WSU Vancouver in 1999. The clones included in this planting are selections that have performed well at WSU Puyallup, but have not been adequately tested at WSU Vancouver. Promising clones that could be included in this planting are WSU 1068, WSU 1090, WSU 1112 and WSU 1145.This planting will need to be maintained and the plants trained. It will be harvested for yield in 2001 and 2002.

## ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

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

## PROPOSED BUDGET:

Support is requested for harvest costs and maintenance of raspberry plots at WSU Vancouver. This will include obtaining posts, wire, and herbicides. Travel would be to local grower meetings and to research plots.

| **Budget:** | **1998-99** | **1999-2000** |
|---|---|---|
| 01 Timeslip Labor | 4,500 | 4,500 |
| 03 Service and Supplies | 1,380 | 1,380 |
| 04 Travel | 150 | 150 |
| 07 Benefits | 720 | 720 |
| **Total** | **(Requested) $6,750** | **$6,750** |
| | **(Received) $2,000** | |

**Project:** 13C-3755-8641

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

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

**Reporting Period:** 1998

**Accomplishments:**
In 1998, the planting established in 1994 was harvested for the third time (Table 1). WSU 1024 had the highest yield in 1998 and the highest three-year total. WSU 1035 the second highest yields in 1998 and did not differ from WSU 1024 and Meeker. Comox and Malahat had very low yields in 1998 as a result of root rot.

The planting established in 1996 was harvested for the first time in 1998 (Table 2). Some weak planting stock and root rot at the site resulted in missing plots and high variability. Among those represented by three replications, Meeker had the highest yield and WSU 1024 was second. BC 86-6-15 had one plot that was healthy spring 1998 that died prior to harvest. The remaining plots of BC 86-6-15 were high yielding. As a result of problems with root rot in the 1994 and 1996 plantings, the planting established in 1998 was established on raised beds.

**Presentations:**

July 1998. Small Fruit Open House, Mt. Vernon, WA.

Table 1. 1996-98 harvest data for 1994 planted raspberries, Mt. Vernon, WA.

| | Yield (t/a) | | | | | | Harvest Season | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Clone | 1998 | 1997 | 1996 | Total | Fruit Rot (%) | Fruit Weight (g) | 5% Harvest | 50% Harvest | 95% Harvest | Length of Season |
| **WSU 1024** | 12.7 A | 15.7 A | 14.8 A | 43.2 A | 1.8 A | 3.3 A B | 6/27 A - C | 7/9 A | 7/26 A | 29 A |
| Meeker | 10.9 A | 13.9 A B | 11.6 A | 36.5 A B | 1.8 A | 2.8 B | 6/29 A | 7/9 A | 7/23 A | 24 B C |
| Comox | 5.3 B | 12.0 B | 16.1 A | 33.3 B | 2.4 A | 3.1 A B | 6/24 B C | 7/5 B | 7/17 B | 23 B C |
| **WSU 1035** | 11.4 A | 11.3 B | 10.4 A | 33.1 B | 2.6 A | 3.4 A | 6/28 A B | 7/10 A | 7/24 A | 26 A B |
| MALAHAT | 5.4 B | 12.7 B | 12.6 A | 30.7 B | 1.2 A | 3.3 A B | 6/22 C | 7/1 C | 7/13 B | 21 C |
| Average | 9.2 | 13.1 | 13.1 | 35.3 | 2.0 | 3.2 | 6/26 | 7/7 | 7/20 | 25 |

Values represent means of three plots of 3 hills.
Means within a column followed by the same letter are not significantly different using Duncan's Multiple Range Test, P=0.05.
Clones indicated by **bold** print have been distributed to growers for grower trial.

Table 2. 1998 harvest data of 1996 planted raspberries, Mt. Vernon, WA

| | Yield (t/a) | Fruit Weight (g) | Fruit Rot (%) | Harvest Season | | | |
|---|---|---|---|---|---|---|---|
| | | | | 5% Harvest | 50% Harvest | 95% Harvest | Length of Season |
| **Clones represented by 3 replications** | | | | | | | |
| Meeker | 12.6 A | 3.2 B | 2.1 A | 6/30 A | 7/13 A | 7/27 A | 27 A |
| **WSU 1024** | 9.4 A | 3.5 AB | 1.3 A | 6/29 A | 7/14 A | 7/28 A | 29 A |
| **WSU 1099** | 7.7 A | 3.8 A | 2.2 A | 6/27 A | 7/10 B | 7/24 A | 27 A |
| **WSU 1096** | 6.4 A | 3.3 B | 2.7 A | 6/22 B | 7/4 C | 7/17 B | 25 A |
| **Clones represented by 2 replications** | | | | | | | |
| BC 86-6-15 | 10.1 A | 3.5 A | 1.4 A | 6/23 B | 7/7 B | 7/18 B | 25 A |
| Malahat | 6.5 A | 3.8 A | 2.1 A | 6/22 B | 7/7 B | 7/18 B | 26 A |
| Willamette | 6.0 A | 2.9 A | 1.8 A | 6/21 B | 7/4 C | 7/16 B | 25 A |
| NY-7 | 3.7 A | 4.0 A | 3.4 A | 7/2 A | 7/14 A | 7/27 A | 25 A |
| **Clones represented single plots** | | | | | | | |
| **WSU 1082** | 9.6 | 5.3 | 9.3 | 7/1 | 7/12 | 7/26 | 25 |
| Comox | 9.1 | 3.7 | 2.1 | 6/27 | 7/13 | 7/27 | 30 |
| **WSU 1098** | 8.8 | 3.0 | 2.5 | 6/27 | 7/9 | 7/23 | 26 |
| Tulameen | 5.8 | 3.7 | 3.5 | 7/2 | 7/13 | 7/27 | 25 |
| ORUS 2078 | 5.2 | 4.1 | 3.2 | 7/3 | 7/18 | 8/1 | 29 |
| Average | 7.8 | 3.7 | 2.9 | 6/27 | 7/10 | 7/24 | 26 |

Values represent means of 3 hill plots.
Means within a column followed by the same letter are not significantly different using Duncan's Multiple Range Test, P=0.05.
Clones indicated by **bold** print have been distributed to growers for grower trial.

**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:** 1999
**TERMINATING YEAR:** 1999

**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 the second time in 1999.

2. A new replicated planting of raspberry clones was established at WSU Mt. Vernon in 1998. The clones included in this planting are selections

that have performed well at WSU Puyallup, but have not been adequately tested at WSU Mt. Vernon. Because of root rot in previous plantings, the new planting was established on raised beds. This planting will need to be maintained and the plants trained. It will be harvested for yield in 2000 and 2001.

## ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

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

## PROPOSED BUDGET:

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

| **Budget:** | **1998-99** | **1999-2000** |
|---|---|---|
| 00 Salaries | | |
| Agr. Res. Tech 0.10 FTE | $2,785 | $2,785 |
| 01 Timeslip Labor | 2,000 | 2,000 |
| 03 Service and Supplies | 576 | 576 |
| 04 Travel | 150 | 150 |
| 07 Benefits | | |
| Agr. Res. Tech. | 919 | 919 |
| Timeslip | 320 | 320 |
| **Total** | **(request) $6,750** | **$6,750** |
| | **($5,000 funded)** | |

## Current & Pending Support

| Name (List PI #1 first) | Supporting Agency & Project # | Total $ Amount | Effective and Expiration Dates | % of Time | Title of Project |
|---|---|---|---|---|---|
| Moore, P.P. | Pending: Northwest Ag. Res. Foundation | $5,998 | 1999-2000 | | Evaluation of small fruits at WSU Mount Vernon |

**PROJECT NO: 13C-3543-5967**

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

**PERSONNEL:** ***Co-Principal Investigators***

**Lynell K.Tanigoshi,** Associate Entomologist, WSU Vancouver REU
**Chuhe Chen, Stephen F. Klauer,** Research Associates, WSU Vancouver REU
**Peter R. Bristow**, Associate Plant Pathologist, WSU Puyallup REC
**J. Scott Cameron,** Superintendent & Assistant Dean, WSU Vancouver REU

**COOPERATORS:**

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

**REPORTING PERIOD: 1998**

**ACCOMPLISHMENTS:**

The innovative model for a satellite facility in northern Washington has continued to gain support from the red raspberry industry and to gain new partnerships. In terms of research accomplishments, the project made very significant progress in entomology, horticulture and plant pathology. With regard to education and outreach, a number of successful extension educational events were held at the satellite facility this year. 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 activities in the northern and southern arenas across the entire industry.

**GENERAL ACCOMPLISHMENTS FOR THE YEAR:**

1. Satellite research model was further evolved in partnership with industry.
2. Chemical control of root weevils and spider mites was studied with promising results.
3. Root weevil and spider mite population dynamics were studied.
4. Winter injury research profiled perennial damaged plants in susceptible sites.
5. Standard and split trellises were compared with promising results.
6. Determined when floricanes and primocanes became infected with the spur blight fungus so that fungicide timing could be improved.
7. Documented the widespread resistance of *Botrytis cinerea* to the main fungicides used to control gray mold fruit rot.

**RESULTS:**

***Entomology***

The first adult clay colored weevil (CCW) was detected from the soil on March 11. This established the biofix for CCW adult emergence as March 11. By March 26, counts from beating tray sampling had increased to 25 CCW/10 trays based on a random sample taken in this field. At this time, light feeding damage was underway and the most advanced fruiting lateral buds were up to 2" long.

Three treatments (i.e., Alert, full rate of Brigade, and basal Brigade) reduced adult CCW populations by 85-90% 14 DAT compared with the untreated check. In the untreated check, counts 14 DAT averaged almost 30 CCW per 10 ft of row. First emergence and biofix for black vine weevil (BVW) in Skagit County was on May 7, 1998 and May 11 in Whatcom County. Most adult BVW had completed emergence by late May to early June. Adult BVW were detected with beating tray samples on 2 of 3 farms in mid to late-May. Counts generally increased by mid-June with the highest count at any site of 5 BVW/10 trays. At this farm, night counts were compared with daytime counts which revealed that sampling with a beating tray at night produced 3 to 10 times more BVW.

Oblique banded leafrollers (OBLR) did not reach significant levels in either field in Whatcom County. OBLR activity was extremely low in the Skagit County field based both on trap catch and examination of lateral shoot tips during April and May. However, orange tortrix (OT) trap catch averaged well over 100 moths/trap/week from late April until late June in Skagit County. The long-awaited OT larval hatch was detected in the third week of June, infesting 5-10% of hills on average. Bt formulations of Javelin and MVPII provided adequate leafroller and armyworm control.

As we have observed in the past, spider mite dynamics and interaction with predatory mites are highly variable from field to field. In the Skagit field, two-spotted spider mites (TSSM) began to increase in late July. In the IPM plot, counts increased rapidly to 40 mites per leaflet by August 10 with no response from the predatory mite, *Neoseiulus fallacis*. Vendex was applied shortly thereafter. It suppressed the population for a week or so but TSSM rebounded by late August to 80 mites per leaflet. TSSM in the traditional plot increased rapidly in mid-August reaching a density of 120 mites per leaflet by the end of the month. This traditional portion of the field was never sprayed. There was never a response from predator mites in either plot in this field.

In one Whatcom County field that has a recent history of yellow spider mite (YSM) infestation, YSM had increased to 40 mites/leaflet in mid-June. The population crashed following a full canopy pre-harvest Brigade spray but began to rebound in late July. There was a strong response from *N. fallacis* beginning in early July. The predator continued to increase during August, reaching a density of 8 predators/leaflet preying on a YSM population of 40 mites/leaflet/ in late August. This predator:prey ratio (.2) is favorable for biological control of spider mites. It was not necessary to spray YSM in this field. The

other Whatcom County field had a low population (1-5/leaflet) of European red mites (ERM) during June and most of July. The population increased in August peaking at about 30 ERM/leaflet by the end of the month. However, due again to a strong response from *N. fallacis* throughout August, favorable predator:prey ratios (.05 to .3), and limited feeding damage for this late in the season, acaricidal control was not warranted. However, this was the highest recorded ERM population on raspberries in Whatcom County to date.

***Horticulture***

SPLITTRELLIS. Over the last two years, the split trellis has performed differently than the conventional trellis in a number of ways. Increased light levels within the split canopy has consistently resulted in increased leaf number, leaf area, and berry number throughout the canopy, but particularly in the upper parts of the canopy where we've documented more light is available early in the season. This increased productivity resulted in estimated yields that ranged from 20 - 50% higher than the conventional trellis for the last two years and actual yields that averaged about 20% higher in two locations last year. This year, we expanded the project from two to five sites that included 8 trials with the split trellis (2 in Lynden). Several trellis widths were tried under a variety of field and management practices. Estimated yields remained encouraging and were similar to previous years (20-50%). Actual yields were greater for the split trellis at most locations. Considering that this was the first time the split trellis was picked by machine for an entire season, and in four trials, the results remain promising.

This year a new 20-inch wire-width split trellis site was established in Lynden at Honcoop's farm, and data was collected from a second-year trellis site of the same width at Riverberry. Increased light exposure in the split canopy resulted in larger canopies that had significantly more fruit, leaves and leaf area. By beginning of harvest, split canopies were about 150-165 cm (59-65 in) wide. There was, however, no significant difference between trellis types in primocane growth.

Machine harvest yield was determined for both locations. At Honcoop's, actual yield was 10% higher for the split trellis, but yield was impacted early in the season by premature picking of green fruit and some lateral damage. Last year, at Riverberry, machine picked yields were 33% greater for the split trellis over the first six harvests, before the grower stopped taking data. This year estimated yield was 28% greater for the split trellis but actual yield was impacted significantly by lateral damage. This is very important because it demonstrates that higher yields are sustainable with the split trellis for two consecutive years. These results remain encouraging because we continue to document a sustained large increase of fruit within the split trellis; and while we were unable to harvest all of that fruit in our first full season of machine trials, we developed a clearer understanding of what the problems were. We have proposed some changes for next year's trials to address these issues.

WINTER INJURY. The winter of 1997-1998 was very mild and produced even less injury than the previous winters; thus, this season, we observed and evaluated the process of continued recovery and cane productivity in the red raspberry canopy. The two test sites paired perennially damaged portions of the field versus controls and were in a well managed, productive field and a weaker, less productive field. In contrast to the last two years, the previously cold damaged plots did not show higher levels of cane dieback, % of cane dieback, number of dead or dormant buds per cane, and percent of dead buds at either site. Very few secondary laterals per cane were produced at both sites this year. This supports our observations from previous years that raspberry canes at these sites produce secondary laterals in response to cold damage. For the first time in this study, the damaged plots actually produced higher yields, mainly through a significantly increased berry number per cane at both sites. Similar to last year, leaves of fruiting canes at site two had higher photosynthetic rates at the green fruit and post-harvest stages of the season. In this very mild winter, the control and previously cold damaged plants showed similar lateral numbers per cane. The overall cane size in the different plots was very similar, though the previously cold damaged plants had higher berry numbers per lateral. It seems the newly recovered plants in the previously damaged plots expressed a renewed vigor, working harder to achieve a higher fruit yield. These observations are very important, as it is of great value to understand the allocation of resources in fields attempting to recover from winter injury. Like last year, there were no differences between the plots in leaf nitrogen content. This suggests that nitrogen might not be an issue here, and more attention should be concentrated on other possible factors involved in cold damage such as plant/cold/insect-damage interactions. We observed high populations of clay colored weevils at one of the previously cold damaged sites this year.

***Plant Pathology***

In 1998, we followed the production of airborne ascospores of the spur blight fungus *Didymella applanata* and determined when primocane and floricane leaves became infected. Ascospores were produced from mid-April through late July. During this period there were 8-9 discrete spore shower events lasting from 1-5 days. Spore showers occurred every 7-18 days and we are in the process of correlating these events with weather data collected on-site. Fungicides applied during spring and early summer to control gray mold fruit rot (*Botrytis cinerea)* had no impact on the production of ascospores by *D. applanata*.

Infection of both primocane and fruiting cane leaves occurred between early May and late June. Fungicides applied during this time period (but not before or after) significantly reduced disease incidence. Fungicides applied to control *B. cinerea* also controlled spur blight; although (as stated above) they did not interfere with ascospore production.

The wedge-shaped leaf lesion, so diagnostic for spur blight, was rarely observed on leaves of primocanes in 1998. The shape of this lesion is thought to be due to rain or irrigation water washing spores to the tip of the leaf, where they germinate and infect because this

part of the leaf stays moist longer than other parts. A combination of little to no rainfall and a buried drip irrigation system in the test field suggest that conditions for this type of infection were rare in 1998. Instead, numerous small necrotic lesions surrounded by yellow leaf tissue were observed. These lesions were usually centered on a vein.

Laboratory tests documented widespread resistance of *B. cinerea* to both the benzimidazole (Benlate) and dicarboximide (Rovral and Ronilan) fungicides in red raspberry fields in Skagit and Whatcom counties.

**ACKNOWLEDGMENT:**
Special thanks to Curt Maberry Farms for their hospitality and professional courtesy in providing facilities and site based assistance for the satellite project. Also, we acknowledge the generous cooperation and commitment extended by Raj Bathe, Frank DeVries, Jerry Dobbins, Rolf Haugen, George Hoffman, Randy Honcoop, and Dave Youngquist for allowing us to work in their fields. 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: 1998 TERMINATING YEAR: 1999**

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

**PERSONNEL:** ***CO-Principal Investigators***

**Lynell K. Tanigoshi**, Associate Entomologist, WSU Vancouver REU
**Chuhe Chen**, **Stephen F. Klauer**, Research Associates, WSU Vancouver REU
**Peter P. Bristow**, Associate Plant Pathologist, WSU Puyallup REU
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**COOPERATORS**

**Craig MacConnell, Chair**, Whatcom County WSU Coop. Extension
**Arthur L. Antonelli**, Extension Entomologist, WSU REC Puyallup
**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. It 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 traveled 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:**

1. Establish base of operations for locally managed, joint, interdisciplinary projects under the direction of Drs. Tanigoshi, Klauer, Chen 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. Enhance the role of WSU Cooperative Extension in integrated pest management education and cultural management 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. Traditional factors for consideration are pesticide induction, horticultural practices, negative impacts on natural enemies (i.e., pesticide selectivity) or phenomenon of competitive displacement. Furthermore, we reported the first finding of economic levels of McDaniel spider mite in Washington state from Clark County in 1997. 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 strategies of chemical, biological and pest resistant plants. Interdisciplinary collaboration 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 winter hardiness and yield efficiency. We will continue to focus these projects and more fully integrate them with issues related to pest/disease management.

***Plant Pathology.*** Red raspberry growers in northwest Washington sustained significant losses due to gray mold fruit rot (*Botrytis cinerea)* in 1997 and in 1998. These losses occurred despite the use of registered fungicides. Isolates of the *B. cinerea* from field in Skagit and Whatcom counties were found to be resistant to both benzimidazole (Benlate) and

dicarboximide (Rovral and Ronilan) fungicides. Berries that rotted in the field before harvest represent a direct loss, but more important economically were the losses associated with grade reductions due to mold lowering the quality of harvested fruit. Many berries that could only be sold for juice stock looked like they had IQF quality at the beginning of harvest before gray mold fruit rot developed. Because control of spur blight is linked to the control of gray mold fruit rot, New methods of gray mold control need to also include control of spur blight. Both diseases are influenced by the environment within the plant canopy and altering the trellis system may reduce pressure from these two diseases.

**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 fourth year phase of the satellite station should further 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 more 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 continue to include growers within the decision 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 consensus 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 feasibility or economic life of both strategies.

***Entomology.*** Insecticide of choice for the traditional program since 1993 has been Brigade (Sect. 18) 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 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 population dynamics; 2) conservation or disruption of spider mite natural enemies after applying root weevil adulticides as a basal spray compared with a traditional full coverage spray; 3) cutworm and aphid build-up and potential for other insect contaminants after applying malathion as a clean-up spray; 4) DD model to predict adult weevil emergence and cessation of their preovipositional period; and 5) increased incidence of 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 been trialing in red raspberry for several seasons. These pesticides exhibit modes of action 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 separate 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 quantify 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 fourth year in several locations to examine the relationships of carbon, water, nutrition, and pest phenology with temperature. 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.

This year the winter injury study will be integrated with entomology and plant pathology studies within the split trellis trial. Evidence from Oregon State University showed that looped canes could be more susceptible to winter injury. We will compare looped vs. topped canes in the split trellis in this regard. Observations made last year suggested an interaction of weevils with winter injury at one perennially cold damaged site. We will evaluate the trellis for any apparent winter injury/pest/disease interaction.

Plots of conventionally trained and split trellis trained 'Meeker' will again be compared in Lynden to compare yields of the two training systems. This year was the first large-scale test of the trellis as we expanded it from two to five sites in north and southwest WA with a total of 8 different trials. The trials tested a variety of split widths, crossarm styles, machine harvesters, and were located in fields that varied in soil type, irrigation and cane training practices. Machine-picked yields were obtained for the entire year for the first time since the inception of this experiment, and in four different locations (2 in Lynden). Results were encouraging as we continued to see increased actual and estimated yields in most trials of the split trellis. We also have gotten an increased understanding of problems that need to be addressed as we work to deliver this new system for industry use. We have obtained federal dollars to fine-tune the system at our research station, but feel it is critical to continue trials in grower's fields, especially in northwest WA. Because most of the industry is centered there, it is also the best representative location to integrate plant pathology and entomology issues with horticultural ones. We propose to continue the majority of our work at just one site in Lynden (Honcoop's if possible), in an effort to concentrate as much labor/resources as needed to assist the grower/cooperator. We will integrate our work with plant pathologists and entomologists there to gain a better understanding of the dynamics of fungal, insect and spider mite pest interactions within the trellis. In particular *Botrytis* will be compared between the trellis types. This year, Korvan has assured us that they will have a representative visit a trellis site during harvest to provide expertise regarding machine adjustments that might be made to increase yields. We plan to top canes in some rows of the trellis trial to see if it alters the cane/lateral architecture for greater machine harvest yields. We propose to take only yield estimates from the Riverberry site to determine if yield in the split trellis can be sustained for 3 consecutive years. A preliminary cost/benefit analysis will be done to compare the two trellis systems.

***Plant Pathology.*** In 1999, we will test several new fungicides for control of gray mold fruit rot and spur blight. Test materials will have shown activity against *Botrytis cinerea* on other crops. This will be an on-farm trial using application equipment similar to that used by growers. Identifying materials that control both diseases will be important because: 1) fungi causing these two diseases infect the plant during the same time period and 2) some of the fungicides currently used to control gray mold also control spur blight. Plots with canes trained to the conventional and split trellises will be evaluated for gray

mold fruit rot and spur blight. A weather station will be operated at the site to record air temperature, relative humidity, rainfall, leaf wetness, wind speed and solar radiation. In addition, HOBO units will be placed in the plant canopy to monitor temperature and relative humidity. During 1998, spore traps were operated from mid-April through late August (except during harvest) to study production of inoculum by the spur blight fungus. Airborne spores of other fungi, including *Botrytis cinerea*, were trapped along with spores of the spur blight fungus. The spore trap tapes will be examined microscopically for spores of *B. cinerea* and periods of spore production will be compared with on-farm and in-canopy weather data collected at the same time. Again this year, cane and fruit diseases will be monitored in the large-scale field trials comparing standard and IPM derived pest management programs.

**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 | 1999 Request |
|---|---|---|
| 01a Wages (Project manager for 6 months) | $17,000 | $18,600 |
| 01b Wages (Temporary employees) | 3,600 | 7,500 |
| 03 Supplies and services (field supplies, analyses) | 3,000 | 1,800 |
| 04 Travel (to sites) | 2,800 | 2,000 |
| 05 Equipment (environmental monitoring) | 2,000 | ---- |
| 07 Benefits (29% of 01a) | | 5,400 |
| 07 Benefits (16% of 01b) | 3,300 | 1,200 |
| **TOTAL** | $31,700 | $36,500 |

Note: In 1998, this project was funded at a level of $31,000 by the WA Red Raspberry Commission ($15,000) and the Northwest Agriculture Research Foundation ($16,000). The actual cost of the project was $35,374, supplemented from other sources on an emergency basis.

**IN-KIND INDUSTRY SUPPORT:**
Office space, living quarters, access to field plots, help with plot maintenance & data collection.

**MATCHING WSU SUPPORT:**
State vehicles, equipment (microscopes, computer, FAX, lab equipment), graduate student support, research scientists' time.

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

**ACKNOWLEDGMENT:**
Special thanks to Curt Maberry Farms for their hospitality and professional courtesy in providing facilities and site based assistance for the satellite project. Also, we acknowledge the generous cooperation and commitment extended by Raj Bathe, Frank DeVries, Jerry Dobbins, Rolf Haugen, George Hoffman, Randy Honcoop, and Dave Youngquist for allowing us to work in their fields. This cooperative model would have never developed without the assistance and support of the industry.

**Project No.: 13C-3543-6967**

**Title: Twospotted Spider Mite Resistance in Red Raspberry Research**

**Year Initiated: 1996**
**Current Year: 1998**
**Terminating Year: 1999**

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

**Reporting Period:** 1998

**Results:**
***Primary field screening of seedlings.*** We were unable to induce economic levels of twospotted spider mites for our planned final field screening at WSU Vancouver REU last season. We will re-evaluate the primary screenings in Block 5, rows 6-18 in 1999 as described in the proposal protocol.

***Advanced screening/Rubus* National Germplasm.** Fifteen *Rubus* spp. from the National Germplasm Collection (Dr. Finn) and seven WSU breeding selections and three cultivars selected by Dr. Moore were replicated four times and propagated in an unheated greenhouse. Twospotted spider mite infestations were monitored from three leaflets/plant and sampled five times during the 1998 growing season. Six *Rubus* spp. and two of the seven breeding selections expressed one-third as many or fewer spider mites as 'Willamette' after the 2 September count. These advanced screenings will be planted at WSU Vancouver REU and at a yet to be determined site in northern Washington.

***Black vine weevil screening/Rubus National Germplasm.*** Using the same plants for the twospotted spider mite screening, we conducted a black vine weevil feeding and ovipositional 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 twelve weeks of feeding, *Rubus nivea* (32%) and WSU 1174 (22%) averaged one-third less as many black vine weevil eggs/leaf and *R. pungens* (38%) compared with 'Willamette'. When comparing black vine weevil adult feeding data as the average leaf eaten in $mm^2$ on 'Willamette' with *Rubus nivea, R. pungens* and WSU 1174, the later deterred feeding by 40, 25 and 62% respectively (Table 2).

**Table 1.**
**1998 Rubus National Germplasm Plants**
Three leaflets from each plant on each date. Four plants per clone.

| Clones: | | Total # Mites | Avg./three leaflets | % Willamette |
|---|---|---|---|---|
| | | Jul.8 & 22 & Aug. 5 & 19 & Sept.2 | | |
| **Cultivars:** | | | | |
| P. Cherry | | 1590 | 27 | 21 |
| Dormanred | | 1718 | 29 | 22 |
| Willamette | | 7680 | 128 | 100 |
| **Breeding selections:** | | | | |
| WSU 1176 | | 2172 | 36 | 28 |
| WSU 1174 | | 2573 | 43 | 34 |
| **Rubus species:** | | | | |
| parviflorus | 1B | 1011 | 17 | 13 |
| innomenatus | 1C | 1291 | 22 | 17 |
| innomenatus | 1A | 1928 | 32 | 25 |
| niveas | 1A | 2119 | 35 | 28 |
| sacchalinensis | 1A | 2413 | 40 | 31 |
| corchorifolius | 1B | 2445 | 41 | 32 |
| pungens | 1A | 2595 | 43 | 34 |

**Table 2.**
**Black Vine Weevil Screening, WSU / Rubus National Germplasm.**

| Clones: | Avg. Weevil Day1 | % Willamette/Weevil Area / mm2 | % Willamette/Weevil Eggs |
|---|---|---|---|
| **Cultivars:** | | | |
| Willamette | 84 | 100 | 100 |
| WSU 968 | 76 | 79 | 62 |
| P. Cherry | 66 | 39 | 33 |
| **Rubus species:** | | | |
| niveas | 78 | 40 | 32 |
| rosifolius | 82 | 83 | 37 |
| pungens | 43 | 25 | 38 |
| innomenatus | 73 | 72 | 43 |
| lambertianus | 82 | 144 | 44 |
| sacchalinensis | 50 | 74 | 44 |
| eustephanos | 59 | 88 | 49 |
| parviflorus | 69 | 97 | 53 |
| sumatranus | 84 | 80 | 56 |
| flosculosus | 71 | 77 | 58 |
| tephrodes | 53 | 72 | 58 |
| **Breeding selections:** | | | |
| WSU 1174 | 71 | 62 | 22 |
| WSU 1170 | 84 | 67 | 36 |
| WSU 1177 | 84 | 114 | 53 |
| WSU 1173 | 76 | 94 | 55 |
| WSU 1169 | 83 | 118 | 58 |

*1 Maximum weevil days per weevil is 84 day for the twelve weeks.*

**Project No.: 13C-3543-6967**

**Title: Twospotted Spider Mite Resistance in Red Raspberry Research**

**Year Initiated: 1996**
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**Personnel Lynell K. Tanigoshi**, Associate Entomologist, WSU Vancouver REU; **Patrick P. Moore**, Associate Horticulturist, WSU Puyallup REC; **Jeanette R. Bergen**, Agricultural Research Technologist II, WSU Vancouver REU

**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 tolerate some mites so that 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 may reduce or eliminate the need for miticides. Aggressive miticide testing will continue in our pesticide programs.

Two clones of *Rubus, R. parvifolius* 'Cherry' and 'Dormanred' (*R. parvifolius* x 'Dorsett') were found to be very resistant to twospotted spider mites three 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 black vine weevil resistance.
2. Continue to collect and evaluate native *Rubus* clones for spider mite resistance from first year field plantings at southern and northern Washington sites.
3. Continue testing the whole-leaf bioassay to assess the nature of *Rubus* resistance to twospotted spider mite infestations.
4. Incorporate identified resistant and tolerant germplasm in the breeding program.

**Procedures:**

**Objective 1.** Because of light field infestation of twospotted spider mite at the Vancouver REU, objective 1 from last year's proposal will be repeated in 1999. From a total of 921 seedlings representing various crosses we have selected 124 for further testing. These crosses have been cultivated in Block 5, rows 6-18 (WSU-VREU) for three seasons. Each cross will be represented by four plants and spider mite levels will be determined from 4-5 sampling intervals. Each sample will consist of 10 leaflets/seedling that will be brushed with a mite brushing machine and counted under a stereomicroscope. This block's row #6-18 will be sprayed with the pyrethroid Asana to eliminate predators and stimulate twospotted spider mite population increases by late June. Older raspberry seedling in Block 5, rows 1-4 will be bioassayed for adult weevil resistance. Ten middle leaflets/clone will be placed in a vial with water and cotton stopper. The unit and one adult black vine weevil will be placed in a Petri dish and allowed to feed for one week. The unit will be changed weekly and the cohort of 10 females will be fed the same clone for 10 weeks. The surface area eaten will be measured with a Delta-T area meter and eggs oviposited/females recorded.

**Objective 2.** Our advanced screenings of identified resistant *Rubus* spp. from the greenhouse screening in 1998 will be field planted at WSU Vancouver REU and a site in either Skagit or Whatcom counties. The northern site will provide population dynamics data for both the twospotted spider mite and the yellow spider mite. Population levels of both spider mite species will be assessed as described in objective 1.

**Objective 3.** After comparing the leaf disk with a whole leaf bioassay, we determined that the latter method provided a more stable feeding arena for twospotted spider mite colonizing red raspberry foliage. This arena was more easily monitored and manipulated under a stereoscopic microscope. From the 1998 collection of 34 *Rubus* spp. from the National Germplasm Collection, six will be bioassayed along with 'Willamette', 'P. Cherry', WSU 1176 and WSU 1174.

**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 establish a protocol to determine heritability of resistance or tolerance traits. This process could vary widely in its potential complexity.

**ANTICIPATED BENEFITS AND INFORMATION TRANSFER:**

The programs involved in this project already have made progress toward developing a pool of resistant germplasm and understanding 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:**

| | | 1999 |
|---|---|---|
| 00 | Agr. Research Tech. II | $3,000 |
| 07 | Employee benefits (26% of 00) | 780 |
| | Total | $3,780 |

**Project No.: 13J-3543-4977**

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

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

**Reporting Period:** 1998

**Accomplishments:** Over 50 delta wing sticky traps, charged with orange tortrix (OT), *Argyrotaenia franciscana* pheromone lures were placed in caneberries sites in northwestern Oregon and southwestern Washington. These were placed in four sites in Oregon (Sauvie Island, Gresham, Boring and Sandy) and 19 sites in Washington (Vancouver, Ridgefield, LaCenter, Brush Prairie). One marionberry, one boysenberry, two blackberry and 28 red raspberry fields were included at 19 sites. Three tortricid leafroller species were monitored: orange tortrix, obliquebanded leafroller (OBLR), *Choristoneura rosaceana*, along with the recently identified carnation tortrix (CT), *Cacoecimorpha pronubana*. In the past two seasons, populations of leafroller larvae were commonly present in the fields after harvest to allow for spray trials; this year larval populations were very scarce after harvest. One field trial was conducted for orange tortrix efficacy at the WSU Vancouver Research and Extension Unit.

**Results:** The voluminous pheromone trap data has yet to be fully analyzed but the following empirical observations were made. Orange tortrix occurred much earlier in marionberry than red raspberry at the same sites. On March 29, OT trap counts in marionberry were over 200 moths/trap/week while trap counts in red raspberry remained below 10 moths/trap/week until 26 April, and never exceeded 100 until 10 May. Orange tortrix field levels varied widely with some sites consistently over 150 moths/trap/week and others never exceeding more than 2 males/trap/week. No distinct trend was apparent between male trap count and the major egg hatch that occurred in early June. OT larvae were never observed or recovered with a beating tray in red raspberry fields from April through the egg hatch period in early June. High male counts in traps were not indicators of larval presence, but were correlated with the high egg hatch in June. Carnation tortrix occurred in significant numbers (20-50/trap/week) in OT traps at four fields located at WSU-REU, Brush Prairie, Boring and Gresham. Though the male flights for both OT (Table 1) and CT (Table 2) overlap, those for CT extend from mid-May to mid-June, while peak first generation OT flight extends from mid-April through late-June with a second generation flight occurring by mid-July into August. A second generation CT flight was detected at the WSU Vancouver REU by late July.

It remains unclear why the fairly target specific insecticides tested (Table 3) for OT larval control performed poorly when compared with the untreated check. Several of the insecticides are considered to be excellent micro-lepidopteran controls throughout the world. Because the potential for OT larval contamination did not occur as expected during red raspberry harvest, larval population densities for multiple treatment sites were not adequate to justify efficacy trials. We are requesting further funding to anticipate multiple treatment applications next year. Of

special interest was the failure of Brigade to kill OT larvae when applied as a topical application in the laboratory. Ten larvae that had survived a field treatment with 0.1 lbs AI/acre were retreated with red raspberry foliage at the same rate under a Potter spray tower. These larvae were held in a covered 6" Petri dish for 24 hours. Because none of these larvae were killed after 24 hours, five of them were retreated with Brigade at 0.2 lbs AI/acre and after 48 hours there still was no mortality for either treated groups. We need to conducted further laboratory bioassays next season to verify the potential for Brigade resistance in different orange tortrix populations.

Table 3. 1998 orange tortrix field trials, WSUREU Vancouver, first year 'Meeker', applied 12 June.

| Treatments | Rate (AI/acre | % Dead | |
|---|---|---|---|
| | | 15 June | 17 June |
| Match (MVP II) | 1.50 | 59.58a | 42.35a |
| Dipel 4L | 1.50 | 60.75a | 42.35a |
| Alert 2SC | 0.32 | 63.96a | 46.32a |
| Success 3.7%FL | 0.09 | 80.00a | 46.67a |
| Proclaim 5SG | 0.01 | 55.27a | 35.25a |
| Confirm 2F | 0.30 | 81.88a | 46.43a |
| Brigade 10WP | 0.10 | 82.86a | 50.00a |
| Untreated check | NA | 52.23a | 32.14a |

Means within columns followed by the same letter are not significantly different ($P<0.05$, LSD).

## Appendix

### Table 1
### ORANGE TORTRIX

| Orange Tortrix Location | Trap # | Week 1 3/23-3/29 | Week 2 3/30-4/5 | Week 3 4/6-4/12 | Week 4 4/13-4/19 | Week 5 4/20-4/26 | Week 6 4/27-5/3 | Week 7 5/4-5/10 | Week 8 5/11-5/17 | Week 9 5/18-5/24 | Week 10 5/25-5/31 | Week 11 6/1-6/7 | Week 12 6/8-6/14 | Week 13 6/15-6/21 | Week 14 6/22-6/28 | Week 15 6/29-7/5 | Week16 7/6-7/12 | Week 17 7/13-7/19 | Week 18 7/20-7/26 | Week 19 7/27-8/2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D Bulb 30 | 1 | 0 | 0 | 2 | 4 | 10 | 17 | 26 | 27 | 15 | 17 | 18 | 14 | 10 | 4 | 0 | 0 | 0 | 10 | 23 |
| D Bulb 50 | 2 | 2 | 0 | 2 | 1 | 3 | 8 | 26 | 33 | 19 | 27 | 16 | 12 | 5 | 0 | 1 | 0 | 4 | 17 | 40 |
| D Bulb 80 | 3 | 0 | 0 | 1 | 0 | 4 | 4 | 12 | 6 | 2 | 7 | 13 | 5 | 3 | 0 | 1 | 0 | 2 | 10 | 6 |
| D Bulb 100 | 4 | 3 | 0 | 2 | 0 | 0 | 2 | 13 | 11 | 11 | 20 | 7 | 6 | 4 | 0 | 2 | 0 | 10 | 9 | 27 |
| D Bulb 125 | 5 | 0 | 0 | 1 | 0 | 1 | 2 | 7 | 5 | 4 | 2 | 4 | | 2 | 0 | 0 | 0 | 1 | 3 | 9 |
| D Bulb 150 | 6 | 1 | 0 | 1 | 1 | 1 | 2 | 4 | 7 | 2 | 6 | 4 | 5 | 2 | 1 | 1 | 0 | 4 | 2 | 4 |
| D Home Older | 7 | 4 | 5 | 18 | 28 | 23 | 110 | 137 | 160 | 165 | 120 | 101 | 75 | 26 | 2 | 3 | 1 | 6 | 4 | 18 |
| D Home 94 | 8 | 16 | 5 | 42 | 43 | 92 | 142 | 139 | 130 | 180 | 160 | 120 | 89 | 35 | 5 | 2 | 0 | 47 | 7 | 18 |
| D Home Back | 9 | 6 | 2 | 17 | 35 | 60 | 70 | 120 | 160 | 175 | 160 | 125 | 115 | 50 | 4 | 1 | 5 | 80 | 5 | 50 |
| D Home Front | 10 | 29 | 7 | 39 | 35 | 85 | 140 | 129 | 145 | 160 | 165 | 160 | 130 | 72 | 3 | 1 | 3 | 62 | 5 | 67 |
| D Baby East | 50 | | | 16 | 0 | 2 | 8 | 79 | 30 | 13 | 17 | 18 | 8 | 5 | 1 | 0 | 0 | 4 | 5 | 13 |
| D Baby West | 51 | | | 19 | 18 | 30 | 21 | 60 | 40 | 95 | 60 | 68 | 70 | 28 | 0 | 0 | 0 | 2 | 7 | |
| D Baby Black | 52 | | | 1 | 14 | 33 | 26 | 24 | 30 | 85 | 78 | 80 | 80 | 30 | 3 | 1 | 2 | 14 | 65 | 125 |
| Hoff Felida North | 11 | 2 | | 3 | 1 | 8 | 13 | 70 | 24 | 11 | 60 | 43 | 70 | 42 | 16 | 23 | 14 | 6 | 25 | 47 |
| Hoff Felida South | 12 | 2 | | 3 | 2 | 3 | 7 | 78 | 64 | 40 | 60 | 54 | 57 | 115 | 30 | 70 | 46 | 22 | 17 | 85 |
| Hoff Canyon | 13 | | | 0 | 1 | 3 | 17 | 70 | 16 | 22 | 48 | 49 | 35 | 50 | 23 | 47 | 26 | 22 | 11 | 13 |
| Herg South | 14 | | | 0 | 5 | 2 | 9 | 46 | 36 | 22 | 58 | 33 | 62 | 52 | 16 | 37 | 35 | 17 | 40 | 105 |
| Hoff 188th East | 15 | | 3 | 3 | 0 | 1 | 8 | 34 | 19 | 26 | 35 | 28 | 30 | 20 | 4 | 4 | 5 | 20 | 17 | 50 |
| Hoff 188th West | 16 | | 1 | 0 | 0 | 1 | 5 | 50 | 21 | 27 | 39 | 12 | 27 | 14 | 1 | 3 | 5 | 5 | 20 | 43 |
| Hoff Home Older | 17 | | 0 | 0 | 0 | 2 | 22 | 25 | 23 | 25 | 26 | 29 | 55 | 38 | 19 | 49 | 25 | 8 | 12 | 16 |
| Hoff Home Babies | 18 | | 0 | 1 | 1 | 1 | 0 | 10 | 18 | 13 | 17 | 30 | 35 | 43 | 23 | 48 | 22 | 31 | 12 | 12 |
| Herg Home | 19 | | 1 | 0 | 2 | 3 | 16 | 60 | 37 | 80 | 80 | 66 | 70 | 45 | 35 | 41 | 27 | 35 | 19 | 15 |
| Hoff River 20N | 20 | 0 | | 0 | 0 | 0 | 4 | 45 | 24 | 15 | 65 | 26 | 37 | 19 | 7 | 5 | 3 | 5 | 2 | 9 |
| Hoff River 20S | 21 | 1 | | 0 | 0 | 1 | 5 | 20 | 23 | 23 | 38 | 40 | 35 | 20 | 4 | 16 | 1 | 5 | 3 | 6 |
| Hoff River 70 | 22 | 0 | | 0 | 0 | 1 | 1 | 17 | 22 | 10 | 7 | 25 | 17 | 9 | 2 | 3 | 0 | 0 | 3 | 7 |
| Hoff River 110 | 23 | 1 | | 0 | 0 | 1 | 7 | 5 | 13 | 12 | 20 | 15 | 22 | 14 | 5 | 13 | 3 | 5 | 11 | 30 |
| Straub South E | 24 | 0 | | 2 | | | 4 | 72 | 33 | 37 | 62 | 107 | 75 | 40 | 3 | 0 | 1 | 1 | 4 | 11 |
| Straub South W | 25 | 1 | | 1 | | | 6 | 18 | 30 | 11 | 21 | 25 | 57 | 13 | 4 | 2 | 0 | 1 | 2 | 6 |
| Straub North N | 26 | 1 | | 3 | 1 | 4 | 5 | 47 | 51 | 22 | 26 | 23 | 21 | 12 | 2 | 8 | 4 | 4 | 7 | 8 |
| Straub North S | 27 | 2 | | 5 | 7 | 8 | 12 | 49 | 29 | 27 | 39 | 20 | 26 | 50 | 7 | 15 | 1 | 4 | 11 | 15 |
| C Genny's East | 30 | | 18 | 11 | 25 | 26 | 75 | 130 | 82 | 50 | 90 | 78 | 43 | 25 | 2 | 2 | 0 | 1 | 2 | 20 |
| C Genny's West | 31 | | 28 | 13 | 60 | 110 | 150 | 160 | 155 | 53 | 27 | 105 | 125 | 50 | 5 | 1 | 3 | 2 | 8 | 26 |
| C Joe's 20 | 32 | | 61 | 21 | 85 | 75 | 135 | 150 | 125 | 90 | 175 | 110 | 80 | 70 | 1 | 2 | 4 | 1 | 2 | 14 |
| C Joe's 70 | 33 | | 37 | 12 | 75 | 85 | 140 | 170 | 156 | 100 | 140 | 85 | 120 | 69 | 1 | 2 | 1 | 3 | 0 | 10 |
| Columbia Rasp E | 39 | 0 | 0 | 1 | 2 | 12 | 41 | 129 | 120 | 55 | 90 | 57 | 89 | 62 | 26 | 20 | 36 | | | |
| Columbia Rasp W | 40 | 0 | 0 | 0 | 3 | 6 | 28 | 74 | 59 | 28 | 27 | 59 | 55 | 70 | 21 | 8 | 22 | | 93 | |
| Columbia Black | 41 | 32 | 18 | 39 | 22 | 143 | 145 | 111 | 239 | 212 | 128 | 93 | 152 | 149 | 203 | 124 | 118 | | 78 | |
| Columbia Boysen | 42 | 42 | 26 | 61 | 17 | 173 | 152 | 165 | 170 | 84 | 163 | 103 | 155 | 152 | 137 | 121 | 125 | | | |
| Columbia Mar N | 43 | 210 | 85 | 152 | 67 | 123 | 214 | 103 | 187 | 211 | 125 | 86 | 154 | 122 | 86 | 73 | 133 | | | |
| Columbia Mar S | 44 | 200 | 103 | 163 | 96 | 147 | 192 | 165 | 198 | 185 | 148 | 95 | 128 | 171 | 136 | 47 | 104 | | | |
| WSU East | 45 | | | 10 | 6 | 23 | 40 | 6 | 6 | 35 | 40 | 30 | 60 | 58 | 24 | 23 | 21 | 50 | 90 | 80 |
| WSU West | 46 | | | 28 | 19 | 24 | 25 | 5 | 34 | 65 | 48 | 38 | 58 | 85 | 35 | 41 | 19 | 36 | 60 | 75 |
| Henkle-Gresham | 50 | | | | | | | | | 49 | 43 | 54 | 45 | 20 | 42 | 13 | 11 | | | |
| Henkle-Gresham | 51 | | | | | | | | | 5 | 11 | 23 | 30 | 12 | 27 | 2 | 7 | | | |

## Table 2
## CARNATION TORTRIX

| *Carnation Tortrix Location* | *Trap #* | *Week 8 5/11-5/17* | *Week 9 5/18-5/24* | *Week 10 5/25-5/31* | *Week 11 6/1-6/7* | *Week 12 6/8-6/14* | *Week 13 6/15-6/21* | *Week 14 6/22-6/28* | *Week 15 6/29-7/5* | *Week 16 7/6-7/12* | *Week 17 7/13-7/19* | *Week 18 7/20-7/26* | *Week 19 7/27-8/2* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D Home Older | 7 | 0 | 0 | 0 | 0 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| D Home 94 | 8 | 0 | 0 | 0 | 3 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| D Home Back | 9 | 0 | 0 | 0 | 0 | 8 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| D Home Front | 10 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hoff Felida North | 11 | 12 | 1 | 8 | 3 | 19 | 6 | 2 | 1 | 1 | 0 | 2 | 5 |
| Hoff Felida South | 12 | 7 | 1 | 10 | 5 | 15 | 17 | 7 | 2 | 0 | 0 | 2 | 15 |
| Herg South | 14 | 1 | 0 | 1 | 0 | 5 | 13 | 1 | 0 | 0 | 0 | 0 | 0 |
| Hoff 188th East | 15 | 0 | 0 | 2 | 1 | 4 | 5 | 0 | 0 | 0 | 0 | 0 | 2 |
| Hoff 188th West | 16 | 11 | 1 | 2 | 7 | 2 | 6 | 1 | 1 | 0 | 0 | 1 | 6 |
| Hoff Home Older | 17 | 2 | 2 | 1 | 2 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Hoff Home Babies | 18 | 0 | 1 | 1 | 0 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Herg Home | 19 | 0 | 0 | 1 | 0 | 5 | 3 | 0 | 0 | 0 | 0 | 1 | 0 |
| Hoff River 20N | 20 | 0 | 0 | 2 | 0 | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hoff River 20S | 21 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hoff River 70 | 22 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hoff River 110 | 23 | 0 | 0 | 1 | 0 | 4 | 5 | 0 | 0 | 0 | 0 | 0 | 3 |
| Straub South E | 24 | 1 | 0 | 5 | 1 | 5 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Straub South W | 25 | 1 | 0 | 3 | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Straub North S | 27 | 0 | 0 | 1 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| C Genny's West | 31 | 0 | 6 | 7 | 22 | 22 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| C Joe's 70 | 33 | 0 | 4 | 9 | 8 | 8 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| C Home | 34 | 0 | 1 | 3 | 5 | 5 | 2 | 0 | 0 | 2 | 0 | 1 | 2 |
| C Nosko East | 35 | 0 | 2 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Columbia Rasp E | 39 | 0 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | | | |
| Columbia Rasp W | 40 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | | | |
| Columbia Black | 41 | 1 | 12 | 22 | 5 | 3 | 2 | 0 | 0 | 0 | | | |
| Columbia Mar N | 43 | 11 | 8 | 16 | 10 | 9 | 5 | 2 | 1 | 0 | | | |
| WSU East | 45 | 79 | 23 | 17 | 18 | 97 | 26 | 4 | 0 | 0 | 0 | 6 | 28 |
| WSU West | 46 | 38 | 15 | 28 | 11 | 47 | 87 | 3 | 7 | 0 | 3 | 28 | 50 |
| Hinkel-Gresham | 53 | | 6 | 7 | 14 | 36 | 15 | 6 | 1 | 0 | | | |
| Hinkel-Gresham | 54 | | 32 | 46 | 38 | 45 | 21 | 3 | 0 | 1 | | | |

**Project No.: 13J-3543-4977**

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

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

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

**Justification:** The orange tortrix, *Argyrotaenia franciscana,* continues to be a key pest of red raspberries in southwestern Washington and Oregon. This leafroller species expresses two to three generations a year and their larval instars web and feed on foliage and maturing fruit. The traditional control strategy is a chemical program consisting of a prebloom spray in early May and a clean-up spray before harvest. Insecticides registered for these two timing intervals include the organophosphates azinphos methyl (Guthion) and malathion, the carbamate carbaryl (Sevin) and *Bacillus thuringiensis* (Dipel and others). Without the Section 18 for bifenthrin (Brigade), most growers have expressed dissatisfaction with the efficacy of the organosynthetics and timing is critical for Bt. Federal passage of the USEPA's Food Quality Protection Act (FQPA) in August, 1996 has put continued registration of all neurotoxins such as the OPs, carbamates and even pyrethroids at great risk 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. These programs will include strategies such as mating disruption and conservation of a complex of parasitoids and predators identified in commercial fields of red raspberry in the Pacific Northwest.

**Objectives:**

1. Field test several biorational insecticides and newer formulations and biotypes of *Bacillus thuringiensis* for 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 correlation with major egg hatch in June and spray recommendations (timing).

3. Evaluate population dynamics of carnation tortrix attractivity to orange tortrix pheromone lures and associated larval infestations within those fields. Define larval characteristics that will more easily separate OT from carnation tortrix larvae in the field for fieldmen and researchers.

**Procedures:**

1. Replicated field trials will be conducted at several known infestations in Clark and Cowlitz counties and 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 and beating tray sampling for early larval instar activity. These sampling methods will provide empirical data to assess impacts of standard and biorational treatments on the natural enemy complex.

4. Treatments will be full coverage sprays applied with a tractor mounted 6 tank plot sprayer with an over the row boom using 13 D3-25 TeeJet nozzles per row at 200 psi, delivering 89 gal/acre at 3 mph.

**Anticipated Benefits and Information Transfer:** Expanding our biological knowledge of orange tortrix population dynamics, economic injury levels and dispersal behaviors will provide growers with additional inputs needed to make appropriate decisions for when, if necessary, to make properly timed applications of insecticides.

Information from this applied research project will be used to support a request to the IR-4 program and the Washington Pesticide Commission for Pesticide Registration. Because biorationals such as IGRs, microbial insecticides and non-neurotoxic mode of action pesticides (e.g., spinosad, emamectin benzoate, 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 at grower meetings, workshops and field days through the auspices of cooperative extension.

**Budget:**

| | | 1999 |
|---|---|---|
| 01 | Temporary employees | $2,000 |
| 07 | Employee benefits (16% of 01) | 320 |
| | Total | $2,320 |

# *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: | | | | |
| Tanigoshi, L. K. | WSCPR 10A-3143-2080 | $4,280 | 1998-1999 | 5 | Evaluation of Biorational Pesticides for Control of the Orange Tortrix |
| | Pending: | | | | |

A:instructions99/cp2/cm
8/98

**PROJECT NO:** 13C-3555-2783

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

**PERSONNEL:**

**Stephen F. Klauer, Chuhe Chen**, Research Associates, WSU REU Vancouver
**Timothy W. Miller**, Ass't Professor, Weed Science, WSU REU, Mt. Vernon
**J. Scott Cameron**, Director & Ass't Dean, WSU REU, Vancouver
**Carl Libbey**, Research Technologist II, WSU REU, Mt. Vernon

**REPORTING PERIOD:** 1996-1998, *Termination Report (continuation proposed)*

**ACCOMPLISHMENTS:** 1996

1. Collected data for caneburning field trials evaluating Goal (oxyfluorfen) and Ignite (glufosinate) for primocane suppression at several rates.
2. Supporting data for Section 18 for use of GOAL for caneburning in 1996.
3. Support for IR-4 project for glufosinate.
4. Spray additives tested to enhance the efficacy of Ignite, Goal and carfentrazone.
5. A new compound, carfentrazone, was tested.

**RESULTS:** Field trials with GOAL (oxyfluorfen) and IGNITE (glufosinate) continued in Vancouver and Lynden. Plots in Vancouver were seriously impacted by root rot in 1996, and this underscored the potentially critical interaction between chemical caneburning and root rot. Oxyfluorfen and glufosinate provided adequate primocane control as in past years. The efficacy of Ignite was greatly enhanced by the addition of adjuvants. Ignite was tested with 1% Sylgard 309, 1% nonionic surfactant, 1% crop oil, or 2% ammonium sulfate. A new compound trialed in Lynden, carfentrazone, appeared promising for caneburning.

**ACCOMPLISHMENTS:** 1997

1. Collected data for caneburning field trials evaluating Goal (oxyfluorfen), Ignite (glufosinate) and carfentrazone for primocane suppression at several rates.
2. Supporting data for Section 18 for use of GOAL for caneburning in 1997.
3. Support for IR-4 project for glufosinate.
4. 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 significant difference in primocane diameter or height through harvest.

**ACCOMPLISHMENTS:** 1998

1. Collected data for caneburning field trials including Goal (oxyfluorfen), Ignite (glufosinate), and carfentrazone for primocane suppression.
2. Support for IR-4 project for carfentrazone.
3. New compounds and combinations of compounds screened for primocane suppression and ancillary weed control.

**RESULTS:** In ongoing advanced testing trials, GOAL (oxyfluorfen [0.2, 0.4 LB/A]), IGNITE (glufosinate [0.5, 1.0 LB/A]) and carfentrazone (0.025, 0.05, 0.1 LB/A) were again compared for primocane control characteristics in Lynden, WA. Percent burn 26 days after treatment (DAT) and primocane regrowth numbers showed that carfentrazone was "softer" on the plant than the other compounds, but effective, and remains promising. Oxyfluorfen and glufosinate were similar to one another in their reduction of primocane regrowth. While there was no statistical difference in yield between treatments, two rates of carfentrazone showed a trend toward increased yield/plot based on increased cane number/plot. Primocane regrowth was initially effected by the high rate of oxyfluorfen, as these canes were thicker and shorter when first measured, but these differences weren't statistically significant by early September. Similar effects were seen on primocane height with the low rate of glufosinate and carfentrazone.

In another trial, new products were screened. These included Buctril (bromoxynil), Spin-Aid (phenmedipham), Betamix (phenmedipham + desmedipham), Milestone (azafenidin) + Gramoxone (paraquat), Scythe (pelargonic acid), Scythe + Goal (oxyfluorfen), and Visor (thiazopyr) + Goal. The Milestone + Gramoxone treatments showed excellent burn, weed control, and yield (g/m) was highest for these treatments. Other trials with either Scythe or Visor alone, or in combination with oxyfluorfen showed poor burn for either chemical alone, but some combinations with oxyfluorfen gave excellent burn and weed control.

**PRESENTATIONS/PUBLICATIONS:**

Cameron, J.S. 1994. Cane management and cropping efficiency in red raspberry: Where do we go from here? 1994 Western Washington Small Fruit Workshop. Lynden, WA, 10 Dec.

Cameron. J.S. 1995. Red raspberry cane management and cropping efficiency. 1995 North Willamette Small Fruit Meeting. Portland, OR, 11 January.

Cameron, J.S. and M.P. Pritts. 1995. Photosynthesis and maximizing raspberry yields: converting theory into practice. Proc. 1995 North American Bramble Growers' Association Annual Meeting, Orlando, FL, February 9-11.

Todd Kostman, Department of Horticulture and Landscape Architecture. 1995 MS thesis. Carbon dynamics of thigmomorphogenic growth regulation in cultivated Rubus.

Cameron, J.S., Al-Khatib, K., Chen, C., Klauer, S.F., and C. Libbey. 1996. Chemical primocane management with Goal and Ignite. Proceedings of the 38th Annual Lower Mainland Horticultural Improvement Association Grower's Short Course. p. 21-24.

Cameron, J.S., Klauer, S.F., Chen, C., Pritts, M.P., and G. Fernandez. 1996. What you need to know about how raspberries grow. Proceedings of the 38th Annual Lower Mainland Horticultural Improvement Association Grower's Short Course. p. 49-52.

Cameron. J.S. 1996. New trends in cultural and environmental physiology. Speaker and panel moderator. 1996 Northwest Center for Small Fruit Research Ann. Meeting. Portland, OR, Dec. 4.

Cameron, J.S., Strik, B., and P. Bristow. 1996. Raspberry cane management for high yields: A panel discussion. Proceedings of the 38th Annual Lower Mainland Horticultural Improvement Association Grower's Short Course. Feb 7-9.

Cameron, J.S., Al-Khatib, K., Chen, C., Klauer, S.F., and C. Libbey. 1996. WSUV R and E Unit Satellite Station Open House, Lynden, WA, July.

Klauer, S.F., Chen, C. and J.S. Cameron. 1996. Review of raspberry horticultural research in Lynden, WA, Summit meeting, October.

Cameron, J.S., Klauer, S.F. and C. Chen. 1996. Overview of WSUV R and E Unit small fruits horticultural reasearch. NCR-22 Annual Meeting for Small Fruits Research, Stevens Point, WI, Oct. 17-19.

Tanigoshi, L.K., Cameron, J.S., Klauer S.F., Chen, C. and S.R. Booth. 1997. Overview of the new small fruit field research station in Lynden, WA. Western Washington Horticultural Association Convention, Seattle, WA, January 8-10.

Cameron, J.S., Klauer, S.F., and C. Chen. 1997. Impact of open trellising on growth, yield and physiology of red raspberry. 42nd North Willamette Valley Horticultural Society Meeting, Portland, Oregon, January 15-16.

Klauer, S.F., Chen, C. and J.S. Cameron. 1997. Review of raspberry horticultural research in Lynden, WA. Summit meeting, Lynden, WA, September.

Cameron, J.S., Klauer, S.F. and C. Chen. 1997. Overview of WSUV R and E Unit small fruits horticultural reasearch. NCR-22 Annual Meeting for Small Fruits Research, Wichita, KS, Nov. 13-14.

Klauer, S.F., Chen, C. and J.S. Cameron. 1998. Field day at WSUV Research and Extension Unit, Vancouver, WA, July 24.

Klauer, S.F., Chen, C. and J.S. Cameron. 1998. Open house for growers and raspberry industry at WSUV Research and Extension Unit, Vancouver, WA, September 16.

Miller, T.W., Klauer, S.F., Chen, C., and J.S. Cameron. 1998. Review of raspberry horticultural research in Lynden, WA. Roundtable discussion, Lynden, WA, September 29.

Cameron, J.S., Klauer, S.F. and C. Chen. 1998. Overview of WSU small fruits horticultural research. NCR-22 Annual Meeting for Small Fruits Research, Troutdale, OR, October 24-28.

PROJECT NO: 13C-3555-5784

TITLE: ACHIEVING GREATER YIELD EFFICIENCY FOR WASHINGTON RED RASPBERRY PRODUCTION

PERSONNEL:

**Stephen F. Klauer, Chuhe Chen**, Research Associates
WSU Research and Extension Unit, Vancouver
**J. Scott Cameron**, Director & Ass't Dean
**Tom Peerbolt**, Peerbolt Crop Management

REPORTING PERIOD: 1998

ACCOMPLISHMENTS:

1. Yield components and actual yields quantified in the field for the split vs. the conventional trellis for several trials.
2. Machine-picked actual yields quantified for an entire season for the first time for the split vs. conventional trellis.
3. Minimum and maximum effective width of split trellis further clarified.
4. Effect of split trellis on primocane growth further clarified.
5. Environmental data collected in the field in order to study cultural phenology.

RESULTS:

*Split Trellis Training System:* Research with a new, machine harvestable split trellis design has expanded quickly with significant promise and growing widespread interest. Over the last two years, the split trellis has performed differently than the conventional trellis in a number of ways. Increased light exposure within and to the surface of the split canopy has consistently resulted in increased leaf number, leaf area, and berry number throughout the canopy, but particularly in the upper parts of the canopy where we've documented more light is available early in the season. This increased productivity resulted in estimated yields that ranged from 20 - 50% higher than the conventional trellis for the last two years and actual yields that were about 20 - 33% higher in two locations last year.

In 1998, yield of the split vs. conventional trellis was again compared in "Meeker" red raspberry with work at Vancouver focusing on advanced trellis development and technology transfer. Field-testing was expanded from two to five sites in north (Lynden) and southwest (Woodland, Ridgefield, WSUV REU) WA with a total of 8 trials. These tested a variety of widths (28, 36, 43, 46, 51 cm); crossarm styles, machine harvesters, and were located in fields with varied cultural practices. Four trials were machine picked, and in Vancouver, harvest efficiency was studied. For widths over 43 cm, actual yields averaged 10-12% greater for the split trellis while widths less than this showed no increase. As in previous years, estimated yield potential was 20-50% higher for the split

trellis in the 4 trials yield components were collected. Considering that this was the first time the split trellis was picked by machine for an entire season, these results remain encouraging. Differences between actual/estimated yields were due to several factors, including some damage to laterals, harvest inefficiency and poor early fruit release. Yield potential was greater (28%) for the split trellis in a second-year trial, suggesting potential sustainability. In various trials, numerous data were collected including canopy and primocane measurements, above-ground biomass, light interception, and leaf: area, gas exchange, chlorophyll content, 4th derivative spectra, fluorescence, N content and tissue for anatomical analysis. Results were similar to last year. Increased light within the split trellis caused earlier and larger canopy growth and fruit development. There was a large increase in leaf number, leaf area and berry number, particularly in the upper part of the canopy. Increases in yield were again associated with higher lateral numbers/cane. Primocane growth was similar between the two trellis types. Clear physiological/anatomical differences were noted for inner and outer leaves in the canopies of both systems.

***Phenology and Temperature.*** While it takes quite a few years to collect enough climatological data to be a reliable model for plant or pest phenology, we are continuing to learn more about what data should be collected, how, and where. In 1998, we monitored relative humidity, soil and air temperatures within raspberry canopies under study throughout the season. We are attempting to take the limited data we have at this time and compare it with general growth patterns, life cycles, etc. 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.

***Time of Floricane Removal.*** Our hypothesis in doing this study was that floricanes continue to contribute much needed carbohydrates to the root system after harvest to support the following year's crop. Our radioisotope experiments suggested this. The study considered cane removal dates after harvest as well as dates in Sept, Nov and Feb. This preliminary study has given us the information we need to suggest that later removal is beneficial. The problem is quantifying this response in terms of practical implementation in light of potential short and long-term gain. We need more information to recommend a practice that may radically change the timing of labor needs. In 1998, we intended to reestablish this experiment at our new WSUV planting, but decided that these plants, in there first season of fruiting, were not good candidates for this type of evaluation. Next year, the planting should be more fully established and give results that are more representative of grower's plantings.

***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. In 1998, funding and time shortages did not allow for most of these experiments. This work has already generated valuable information with regard to resource allocation in red raspberry and will continue to give us valuable information dealing with the influence of crop load, cultural management and stress on those allocations and thus productivity.

PROJECT NO.: 13C-3555-5784

YEAR INITIATED: 1991 CURRENT YEAR: 1999 TERMINATING YEAR: 2000

TITLE: ACHIEVING GREATER YIELD EFFICIENCY FOR WASHINGTON RED RASPBERRY PRODUCTION

PERSONNEL:

**Stephen F. Klauer, Chuhe Chen,** Research Associates
WSU Research and Extension Unit, Vancouver
**J. Scott Cameron,** Director & Ass't Dean
**Tom Peerbolt,** Peerbolt Crop Management

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

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

OBJECTIVES: (All to be addressed in 1999)

1. Characterize yield potential of the red raspberry plant in relation to cultural practices and cane management regime.
2. Study interplant\intraplant competition and its influence on cultural practices such as optimizing cane density, time of pruning and training systems.
3. Initiate and continue studies with cost effective approaches to recovering yield potential through new trellis design and cane management strategies.

## PROCEDURES:

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

Owing to the significant success of research plot and grower-based trials and widespread industry interest, we established the split trellis as a primary project in 1998. We expanded the project to include multiple sites in north and southwest WA. Results were again promising in this first wide scale test of the trellis, and we made significant progress in identifying and evaluating the issues that will need to be addressed as we move forward with advanced testing of this new system. We propose to continue our studies with this system while studying the components of productivity in conventional and alternative systems. This effectively expands the model of study we were using with an opportunity to set more realistic parameters and to recover more data related to important issues such as labor costs and economic returns.

We will again have at least one site in Lynden to evaluate. In the southern part of the industry, we will assess plots established in Woodland, Ridgefield and our new planting at the Vancouver research station for a second consecutive year. In addition, our Woodland cooperator is establishing 35 acres of split trellised 'Meeker' on his farm; which should give us valuable farm-scale information related to trellis performance and economics. 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.

In 1998 we learned several things including: a better idea of minimum effective width of the split trellis, interactions of various types of machine-harvesters with a split canopy and harvester efficiency, canopy development and architecture within the split trellis, actual and potential yield within the split trellis and factors effecting realized yields. In 1999, we will continue to develop our knowledge in these areas and attempt to realize even greater yields within the split trellis based on what we have learned thus far. This will include comparing topping vs. tying of canes within the split trellis and optimizing harvester picking action while minimizing damage. We will continue to examine crossarm width, mechanical harvest efficiency, yield sustainability 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. In addition, a preliminary cost analysis will be determined for the split vs. conventional trellis. Effectiveness of the split trellis under varied cultural practices will also be evaluated.

***Phenology and Temperature:*** Red raspberry leaves have a 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 1998 | Requested 1999 |
|---|---|---|
| Temporary employees | $7,500 | $7,500 |
| Supplies and services | 1,000 | 1,000 |
| Travel | 800 | 800 |
| Benefits (16% of 01) | 1,200 | 1,200 |
| **TOTAL** | **$10,500** | **$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 and 1998, we have asked Mr. Tom Peerbolt to continue to work with us as a cooperator to oversee some of the harvest and data collection in on-farm plots.*

OTHER SUPPORT OF PROJECT:
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, ROLF HAUGEN, GEORGE HOFFMAN, AND RANDY HONCOOP.

**Project No.:** 13C-3761-7784

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

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

**Reporting Period:** 1998

**Accomplishments:** Two new fungicides were identified as having activity against *Phytophthora fragariae* var. *rubi* under field conditions. Anchor was considerably more active than Acrobat. Curzate, Banol and Fluazinam exhibited no activity against this soil-borne fungus.

**Results:** The mild and rainy weather during winter 1997-1998 favored development of this root disease. Few overwintering canes survived unless they were treated with either Anchor or Acrobat.The dead canes looked healthy in the fall when they were tied to the trellis. Plots treated with either Ridomil or Aliette were not noticeably different than the untreated check. Laterals on plants treated with either Anchor or Acrobat emerged earlier and were more vigorous than those on plants in other plots (Table 1). Many laterals collapsed soon after beginning to grow. While a few primocanes wilted in plots treated with Anchor and Acrobat the highest number of healthy primocanes were produced in plots treated with those two fungicides in m1998. Only plants in plots treated with Anchor were grew enough primocanes in 1998 to produce an adequate crop in 1999. Oxadixyl is the active ingredient in Anchor and Recoil; Recoil is the fungicide used to control this disease on red raspberry in Europe.

Isolates of *Phytophthora fragariae* var *rubi* were obtained from plantings with a history of Ridomil use while other were recovered from sites where the fungicide had not been used. Isolates from both types of sites were equally sensitive to Ridomil. This suggests that the fungus has not developed resistance to the fungicide and the poor disease control in Ridomil treated plots must be due to another cause(s).

## Appendix

Table 1. Plant survival and performance of fruiting canes and primocanes, 1998[z].

| Treatment | Plant Survival %[y] | Fruiting canes: Lateral rating[yx] | Fruiting canes: Cane Vigor rating[w] | Primocanes[u]: % wilt | Primocanes[u]: Healthy canes per plot, no. |
|---|---|---|---|---|---|
| Untreated check | 43 | 1.4 | 0 | 29 | 1 |
| Ridomil | 58 | 1.9 | 0.4 | 20 | 19 |
| Aliette | 60 | 2.1 | 0.6 | 9 | 19 |
| Anchor | 90 | 3.6 | 2.7 | 3 | 189 |
| Curzate | 35 | 1.6 | 0 | 0 | 2 |
| Banol | 30 | 1.5 | 1.0 | 11 | 4 |
| Acrobat | 80 | 2.5 | 1.4 | 10 | 45 |
| Fluazinam | 43 | 2.0 | 0.5 | 26 | 31 |

[z] Planting established on 10 May 1996, with 10 Willamette plants per plot..
[y] Data collected 14 Apr.
[x] 0-4 Lateral emergence rating scale. 0 = no growth and 4 = alive and vigorous.
[w] 0-3 Fruiting cane vigor rating scale. 0 = least vigor and 3 = most vigor. Data collected on 19 Jun and 2 Jul.
[u] Data collected on 2 Jul.

**Project No.:** 13C-3761-7784

**Title:** Evaluating new fungicides for control of Phytophthora root rot and testing soil for enhanced degradation of Ridomil.

**Year initiated:** 1996 **Current year:** 1999 **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 when the plants are young. Meeker, the most widely planted cultivar in the region, is susceptible but expresses some tolerance once fully established. Root rot is the most serious root disease of this high value crop in the Pacific Northwest. The rainy winters in this region favor the production and dissemination of spores of this water-mold fungus. Infection is also favored in wet soils. While the disease is more common on heavy poorly drained soils, it also occurs on sandier soils. Since 1982, the fungicide Ridomil has been used to control this disease. More recently, Aliette was registered for this use but field trials demonstrated that it was not as effective as Ridomil. Also, because it is applied to the foliage it cannot be used at or shortly after planting. Both fungicides, however, have a role to play in controlling this disease. A control program that includes Aliette will help to delay the onset of resistance to Ridomil.

At some sites, Ridomil is less effective than it was in the past. Based on the reaction of isolates of the fungus to Ridomil the lack of performance does not appear to be due to resistance. Whatever is causing the poor performance of Ridomil, alternative chemical control methods need to be identified and developed. Although we did not detect resistance to Ridomil, the potential for resistance still exists. The selection pressure for resistant types is present 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 Anchor and Acrobat for control of this root rot under field conditions and compare their performance to the untreated check and the Ridomil treatment.

2. Initiate experiments to determine if microorganisms in the soil are degrading Ridomil and thus rendering it ineffective in certain sites.

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

**Procedures:** The replicated field planting at WSU Vancouver Research and ExtensionCenter will be continued for one more year. The only treatments to be continued will be the untreated check, Ridomil, Anchor and Acrobat. The fungicides will continue to be applied twice yearly; once in the spring and once in the fall.

Soil with and without a history of Ridomil use will be collected for laboratory tests to measure the rate of disappearance of Ridomil.

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 to control this root disease. The ability to control this disease will give growers more options in the cultivars they grow. Some of the newly released cultivars are susceptible to this disease.

Information from this applied research project will be used to support requests to the IR-4 program and the Washington Pesticide Registration Commission for support for 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 discuss products that are not legal to use on red raspberry. This is especially true for products that are already registered for use on other crops and available in the marketplace.

**Budget:**

| | |
|---|---|
| Allocation for FY1998-99 | $3,220 |
| Request for FY1999-2000 | |
| Timeslip | 2,400 |

| | |
|---|---|
| Operations (goods and services) | 550 |
| Travel | 200 |
| Projected needs | 200 |
| Meetings | 40 |
| Equipment | 100 |
| Employee benefits | 385 |
| Total | $3,875 |

**Other Support for the Project:** Support will be requested from Novartis to help cover the work proposed in Objective 2. 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:** 1998

**Accomplishments:** Data was collected for the first time from the planting established in 1997. This field trial was design to look at the use of: 1) raised beds, 2) Ridomil and 3)high rates of gypsum in an integrated approach to controlling this serious root disease. Tissue culture propagated Meeker and Skeena plants were used in the planting. All three factors reduced disease severity and were the most effective when used together.

**Results:** All of the plants grew well in 1997 and there were no differences between treatments in late fall when canes were cut-off cut just above the soil line. Raised beds (formed just before planting with a commercial bed shaper) at planting were 12+ inches high but by spring of the next year they had settled and eroded to just 9+ inches. As plant growth resumed in spring 1998 treatment differences began to appear. In some plots there was no new growth while in others, particularly those on the raised beds, there was abundant primocane production. Skeena was more vigorous than Meeker and its canes were more upright.

The mild rainy winter not only eroded the raised beds but also maintained soil conditions that were favorable for activity by the root rot fungus. Primocane wilting is a symptom we have used in the past to assess disease severity but this year few primocanes wilted. Apparently, favorable soil conditions resulted in extensive root damage so the number of healthy primocanes was a better measure of disease severity. Plants set in untreated soil of flat beds served as the untreated check for the experiment. Plants of Meeker and Skeena were the poorest in those plots. Plant survival was highest for both cultivars on raised beds (Table 1). The overall vigor and health of plants was reflected in the number of healthy primocanes per plot (Table 2). Raising the plants up has the greatest beneficial effect. Ridomil and gypsum each add an increment of disease control. Plants were the healthiest when all three components were combined. Incorporating high rates of gypsum (6 tons per acre) prior to planting had no impact on soil pH.

The relatively poor performance of Ridomil in flat beds was typical of the level of activity obtained in other plantings at the same site.

While these results are extremely encouraging, it is important to remember that they are just first year results. Red raspberry is a perennial crop so testing needs to continue to see these treatments can continue to protect the plants and sustain production.

## Appendix

Table 1. Plant survival on May 26,1998[z].

| | | Plant survival, %[y] | | | |
|---|---|---|---|---|---|
| Cultivar | Bed type | None | Ridomil | Gypsum | Ridomil + Gypsum |
| Meeker | Flat | 28 | 59 | 91 | 94 |
| | Raised | 97 | 91 | 97 | 97 |
| Skeena | Flat | 83 | 83 | 96 | 96 |
| | Raised | 100 | 100 | 100 | 100 |

[z] Planted July 3, 1997.
[Y] Eight plants per plot.

Table 2. Impact of bed type, Ridomil and gypsum on the number of healthy primocanes.

| | | Healthy primocanes per plot | | | |
|---|---|---|---|---|---|
| Cultivar | Bed type | None | Ridomil | Gypsum | Ridomil + Gypsum |
| Meeker | Flat | 9 | 32 | 59 | 110 |
| | Raised | 85 | 148 | 110 | 187 |
| Skeena | Flat | 37 | 86 | 157 | 181 |
| | Raised | 196 | 254 | 209 | 296 |

[z] Data collected July 2, 1998.

**Project No.:** 13C-3761-6718

**Title:** Integrated control of Phytophthora root rot.

**Year initiated:** 1994 **Current year:** 1999 **Terminating year:** ongoing

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

**Justification:** Root rot, caused by the soil-borne fungus *Phytophthora fragariae* var. *rubi*, is the most serious root disease of red raspberry in the Pacific Northwest. In attempting to develop control measures for this disease, it has become clear that any single approach or method will not provide the level of control required for this high value crop. Since 1982, growers have been able to use the fungicide Ridomil (metalaxyl) and it has successfully controlled the disease at many locations. Increasingly, there are locations where it apparently is no longer effective. In test plots at the WSU-Vancouver Research and Extension Unit, we experienced our first failure in nearly 20 years of working with the fungicide. Aliette (fosetyl-Al) also has activity against *P. fragariae* var. *rubi*, but it has not been as effective as Ridomil. Newer compounds are being tested, but to date only one compound has a high level of activity (Anchor) and it belongs to the same chemical class as Ridomil (hence the chance of cross-resistance). 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 Ridomil. Progress is being made in combining resistance with desirable horticultural traits, but it takes time and there are few 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. After one year of testing in the Pacific Northwest, gypsum tilled into the soil before planting helps to lower disease severity. In order for an integrated strategy to be considered successful on a perennial crop it must be able to sustain production over many years. For that reason treatments must be continued and field plots evaluated for several years.

The goal is to develop an integrated program that controls the disease and gives growers the greatest number of options.

**Objectives:**

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

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

**Procedures:** A field trial was established on a site with a history of Phytophthora root rot. The eight treatments (each replicated three times) will be evaluated on an ongoing basis. Gypsum at a high rate (6 tons per acre) was applied and worked into the soil of designated plots before bed shaping and planting. Soil will continue to be tested pH. Raised beds will be restored to near their original height by throwing soil from the alleyway up around the base of the plants. No additional gypsum will be applied. Tensiometers will be placed in both raised and flat beds to monitor soil moisture. Ridomil will be sprayed on the soil surface each spring and fall. During 1999, symptoms will be recorded, disease incidence and severity evaluated, and cane growth measured at the end of the season. The plots will also be harvested for yield.

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

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

**Budget:**

| | |
|---|---|
| Commission funding for FY1998-99 | $3560 |
| | |
| Request for FY1999-2000 | |
| Timeslip labor | 2,400 |
| Operations | 800 |
| Travel | |
| Projected needs | 300 |
| Meetings | 100 |
| Employee benefits | 385 |
| Total | $3,985 |

**Other Support of Project:** None at this time.

**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:** 1998 (Terminal report)

**Accomplishments:** Two field trials were conducted on a commercial farm near Woodland, WA. Development of yellow rust was followed on leaves of both fruiting canes and primocanes. Disease control from two newer fungicides was compared to that of current standard materials, including, liquid lime sulfur, ferbam and copper hydroxide. Both Orbit and Rally were superior to the standards. Orbit was approved for use under a Section 18 Emergency Exemption. We were unable to evaluate the impact of trellis configuration on this disease because the entire experimental area was treated with Orbit.

**Results:** Few aecia were found on primocane leaves because early flushes of primocanes were removed chemically to control cane vigor. Replacement canes emerged after the spore stage that leads to the formation of aecia. The uredinial stage (yellow pustules on the underside of leaves) was the first stage of the fungus to appear on primocane leaves. The first pustules were found on the lower leaves and the disease progressed up the primocanes as the season advanced. Eliminating the aecial stage on primocanes most likely slows the overall rate of disease increase.

In contrast, rust first appeared on fruiting cane leaves near the top trellis wire. This occurred even though very little leaf debris was trapped between canes where they were bundled together and tied to the trellis. Rust moved down the fruiting canes as the season progressed.

A single application of liquid lime sulfur applied when there was 3-5 inches of new lateral growth did not reduce disease incidence but caused minor burning and distortion of leaves. Copper hydroxide (Kocide) and ferbam (Carbamate) each applied on three dates between late April and late May was only minimally effective. In contrast, outstanding control was achieved with Orbit and Rally applied on the same schedule. Orbit at the 1X and 1.5X rates caused downward cupping of leaves on primocanes and fruiting canes but this slight damage did not

appear to affect production. Few pustules formed on leaves treated with either Orbit or Rally. Consequently, very few teliospores were found in late August, three months after the final application. Overwintering inoculum for 1999 will be extremely low.

Since 1996, thirty nine cultivars and advanced selections from the WSU and other red raspberry breeding programs have been evaluated for their reaction to yellow rust in replicated field plantings. Over 80% were susceptible and only two were resistant (Chilcotin and WSU 520). Very little of the germplasm in the breeding program is resistant, hence the need to develop an integrated control program that will be effective without plant resistance as a component.

Of the 911 seedlings from 15 different crosses with WSU 968 (a mite and aphid resistant selection) less than 20% were resistant to or escaped to yellow rust.

**Publications:**

Bristow, P. R. 1998. New ways to control yellow rust and spur blight. Proc. Lower Mainland Hort. Improv. Assoc. 40:69-70.

Menzies, G. W., Bristow, P. R. and Potter, F. H. 1998. The use of calcium polysulfides (Sulforix) for control of cane diseases, 1997. APS-Fungicide and Nematicide Tests. 53:119.

## Appendix

Table 1. Control of yellow rust on Meeker red raspberry with fungicides, 1998[z].

| Treatment | Application dates | | | | Disease severity rating[y] | |
|---|---|---|---|---|---|---|
| | 3-25 | 4-28 | 5-11 | 5-26 | Primocanes[x] | Floricanes[w] |
| Untreated check | | | | | 4.9 | 5.0 |
| Sulforix | X | | | | 2.8 | 4.7 |
| Carbamate 76 WDG | | X | X | X | 2.9 | 4.5 |
| Kocide 2000 | | X | X | X | 4.6 | 4.5 |
| Orbit 3.6 EC (1X) | | X | X | X | 0.4 | 0.2 |
| Orbit 3.6 EC (1.5X) | | X | X | X | 0.2 | 0.2 |
| Rally 40 WP | | X | X | X | 0.5 | 0.3 |

[z] Commercial field near Woodland, WA.
[y] 0-5disease severity rating scale. 0 = no rust and 5 = most severe rust.
[x] Evaluation on 7-7-98.
[w] Evaluated on 6-9-98.

Table 2. Reaction of different cultivars and advanced selections to *Phragmidium rubi-idaei*.

| Resistant | Intermediate | Susceptible | | |
|---|---|---|---|---|
| Chilcotin | Brandywine | Chilliwack | ORUS 1836 | WSU 1031 |
| WSU 530 | Newburgh | Comox | ORUS 2078 | WSU 1035 |
| | Tulameen | Glen Ample | WSU 968 | WSU 1041 |
| | WSU 1021 | Kiska | WSU 983 | WSU1067 |
| | WSU 1030 | Malahat | WSU 985 | WSU 1068 |
| | | Rosanna | WSU 988 | WSU 1082 |
| | | Schonemann | WSU 991 | WSU 1096 |
| | | BC 85-524 | WSU 994 | WSU 1097 |
| | | BC 86-6-15 | WSU 1007 | WSU 1098 |
| | | NY-7 | WSU 1009 | WSU 1099 |
| | | ORUS 958-10 | WSU 1024 | |

Table 3. Susceptibility of seedlings from various crosses with WSU 968[z] to *Phragmidium rubi-idaei*.

| Cross | Seedlings tested | |
|---|---|---|
| | No. | % susceptible |
| Brandywine (I)[y] X WSU 968 (S) | 34 | 100 |
| Cherokee (?) X WSU 968 (S) | 59 | 81 |
| Chilliwack (S) X WSU 968 (S) | 33 | 85 |
| Glen Ample (S) X WSU 968 (S) | 68 | 82 |
| Meeker (S) X WSU 968 (S) | 31 | 94 |
| WSU 968 (S) X Meeker (S) | 11 | 27 |
| Nootka (?) X WSU 968 (S) | 95 | 83 |
| Schonemann (S) X WSU 968 (S) | 17 | 100 |
| Sunrise (?) X WSU 968 (S) | 101 | 54 |
| Tulameen (I) X WSU 968 (S) | 137 | 81 |
| WSU 530 (R) X WSU 968 (S) | 6 | 33 |
| WSU 991 (S) X WSU 968 (S) | 5 | 100 |
| WSU 994 (S) X WSU 968 (S) | 89 | 97 |
| WSU 1024 (S) X WSU 968 (S) | 112 | 91 |
| WSU 1027 (?) X WSU 968 (S) | 113 | 69 |

[z] WSU 968 is resistant to mites and aphids.

[y] Reaction of parent. R = resistant, I = intermediate, S = susceptible and ? = unknown.

**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
Geoff Menzies, IPM Specialist, WSU-Nooksack IPM Project

**Reporting period:** 1998 (Terminal)

**Accomplishments:** Burkard volumetric spore traps were operated in a commercial red raspberry field. One trap was placed in a block of plants that was not treated with fungicides and the other was in a block that received the cooperating growers standard fungicide program for control of cane diseases and Botrytis fruit rot. On this and a nearby farm, a mixture of Captan and Rovral was applied on several dates to protect plants for different periods during the growing season. In addition, a weather station and HOBO temperature and relative humidity recorders placed at two positions in the plant canopy were maintained at the site with the spore traps. Both sites were in the Northwood area of Whatcom County.

**Results:** We followed the production of airborne spores (ascospores) of the spur blight fungus *Didymella applanata* and determined when primocane and fruiting cane leaves became infected. Spores were produced from mid-April through late July (Figure 1). During this period there were 8-9 discrete spore shower events lasting from 1-5 days. Spore showers occurred every 7-18 days and we are in the process of correlating those events with the weather data collected at the site. Fungicides applied during spring and early summer for control of Botrytis fruit rot did not reduce the production and dissemination of spores of the spur blight fungus.

Infection of fruiting cane leaves occurred between early May and late June (Table 1). Fungicides applied during this time (but not before or after) significantly reduced disease incidence. Leaf infections leading to lesions on primocanes occurred during the same or slightly later period (Table 2). Fungicides applied to control Botrytis fruit rot also controlled spur blight.

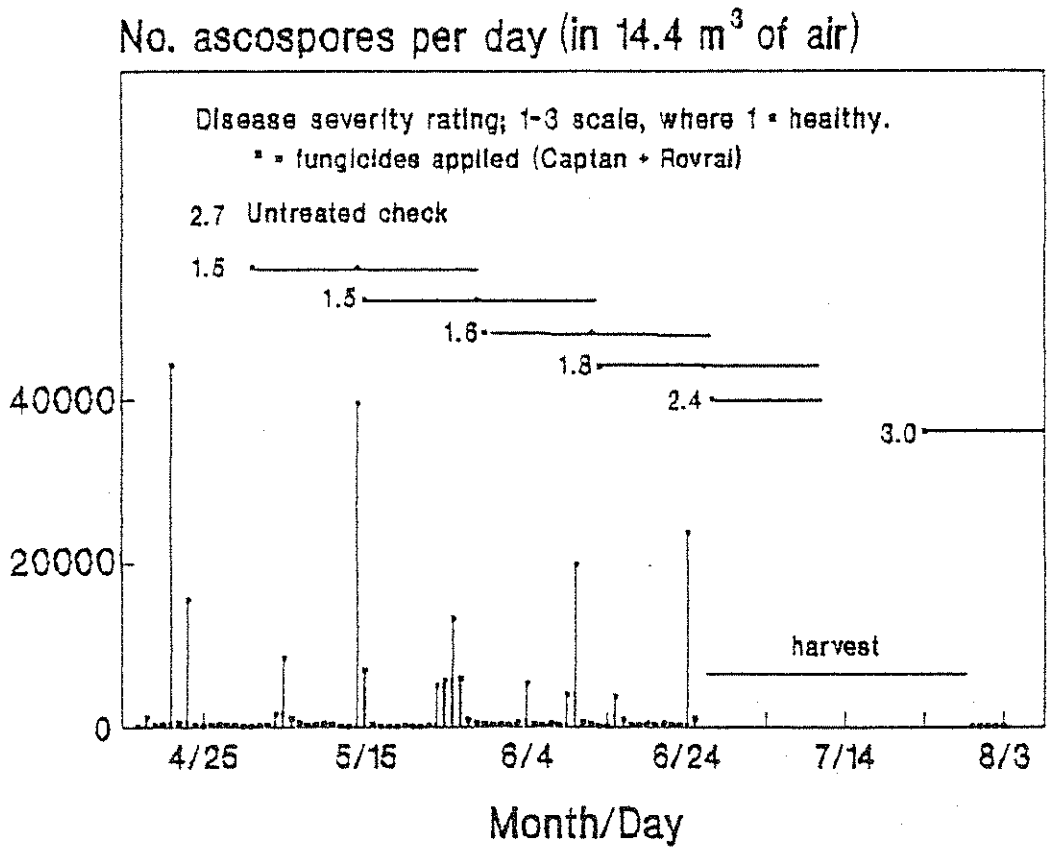
The wedge-shaped lesion on leaves of primocanes, that is considered diagnostic for spur blight, was rarely observed in 1998. The shape of this lesion is thought to be due to rain or irrigation water washing spores to the tip of the leaf where

infection takes place because the leaf tip remains moist for longer periods than other locations on the leaf. A combination of little or no rainfall and the use of a buried drip irrigation system in the test field suggest that conditions for the common type of lesion were rare in 1998. Instead, numerous small necrotic lesions surrounded by a halo of yellow tissue were observed. These lesions were most often associated with a vein.

**Presentations:**

Cane disease research update. WSU-Lynden Satellite Station Open House, September 29, 1998.

Figure 1. Daily catch of ascospores of *Didymella applanata* and severity of spur blight on fruiting cane leaves protected for the indicated periods with fungicides (Captan plus Rovral).



## Appendix:

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

| Fungicide application dates | Disease severity index[z] | |
|---|---|---|
| | Site H | Site N |
| Untreated check | 2.5 | 3.0 |
| May 2 & 15 | 1.5 | 1.6 |
| May 15 & 29 | 1.8 | 1.3 |
| May 29 & Jun 13 | 1.9 | 1.5 |
| Jun 13 & 25 | 2.0 | 1.7 |
| Jun 25 | 2.5 | 2.3 |
| Jul 24 | 3.0 | 3.0 |

[z] 1-3 Disease severity rating scale. 1 = healthy and 3 = most leaf lesions.

Table 2. Disease incidence on primocanes protected by fungicides for different periods[1].

| Fungicide Application dates | Nodes with spur blight, % | |
|---|---|---|
| | Site H | Site N |
| Untreated check | 19.4 a | 35.6 a |
| May 2 & 15 | 8.9 b | 27.3 bc |
| May 15 & 29 | 8.1 b | 27.8 abc |
| May 29 & Jun 13 | 8.5 b | 21.4 c |
| Jun 13 & 25 | 8.3 b | 26.8 c |
| Jun 25 | 11.6 b | 26.4 c |
| Jul 24 | 19.4 a | 34.9 ab |

**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: 1998**

**Personnel:**

Dr. Thierry C. Vrain, Principal Investigator
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Ms. Susan Wahlgren, technician (tissue culture)

**Results:**

The research was severely delayed by lack of personnel. We have regenerated 55 putative transgenic lines, transformed raspberry plants expressing a proteinase inhibitor (OCI) or a lectin (GNA) under the control of AoPR1, a wound inducible promoter. These plants are also expressing the *bar* gene which provides resistance to glufosinate herbicides, so *in vitro* selection was done on regenerating media containing 0.2 mg /L of the herbicide Ignite®. We experienced difficulties attempting to characterize the putative transgenic lines (mostly for lack of personnel). PCR screening of 160 separate transformation events identified 55 positive lines only. Genomic DNA was extracted from 25 mg of leaf tissue using a commercial kit (Quiagen). PCR primers for the *gna*, *ocI* and *bar* genes were used to give products of 377, 300 and 434 bp, respectively. No further molecular characterization of these lines was done before multiplication and rooting in tissue culture (again for lack of personnel). Ten replicated clones of each transgenic line are presently being bioassayed with root lesion nematodes in a greenhouse. It is expected that some lines are expressing a high level of lectin or proteinase inhibitor that will confer resistance to nematodes and insects.

**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; Helena, Agritope, 16160 S.W.Upper Boones Ferry Rd., Building C, Portland, OR 97224.
**Reporting Period: 1998**
**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 six constructs into 'Meeker' raspberry has been carried out and most of the transformants are in tissue culture, a screenhouse or a greenhouse. These transformants have been through a 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.

A minimum of 25 different transformation events are being prepared for each construct and 25 plants of each line are being propagated in tissue culture. Thus far we have 25 or more transformation events for four of the constructs, 23 for the fifth construct and 5 for the sixth construct. Two plants of each construct are being maintained in a greenhouse for graft inoculation with RBDV. PCR tests have been done on a subset of plants to ensure that the genes are present. Plants for field trials are being hardened off in a screenhouse. Field trial applications have been made and approved for both Oregon and Washington. Below is a list of the constructs we are using and the number of transformation events and total plants we have for each event.

Transformation events and number of plants produced for each construct being used for engineering resistance to RBDV.

| Construct | Number of events | Number of plants |
|---|---|---|
| 2171 | 50 | 1064 |
| 2172 | 43 | 710 |
| 2173 | 23 | 319 |
| 2174 | 34 | 446 |
| 2177 | 51 | 1216 |
| 2178 | 5 | 85 |
| **Total** | **206** | **3755** |

**Project No:**

**Title:** Engineering resistance to raspberry bushy dwarf virus

**Year Initiated 1996 Current Year 1999 Terminating Year** 2003

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

**Justification:**

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

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

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

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

**Objectives:**

1. Develop regeneration protocol for several Meeker red raspberry (Accomplished at Agritope).
2. Clone and sequence the coat protein of RBDV (completed).
3. Clone and sequence the movement protein of RBDV (completed).
4. Carry out mutagenesis of movement protein of RBDV (completed).
5. Transform raspberry with coat protein, movement protein and mutated movement protein genes of RBDV (started in 1997, most of effort in 1998).
6. Test transgenic plants for virus resistance in the greenhouse (graft inoculations started in October of 1998).
7. Test transgenic plants in field trials for virus resistance and fruit quality (Set up first field trials in 1999). Applications approved in 1998.

This year we will be addressing objectives 5, 6 and 7.

**Procedures:**

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

**Anticipated Benefits and Information Transfer:**

Virus resistance will increase the life of raspberry plantings by eliminating the crumbly fruit symptom and yield losses caused by this virus. Once developed the regeneration and transformation strategies allows for the easy introduction of additional traits. This may be traits for insect, nematode, or fungal resistance or to add traits that enhance the fruit quality once suitable genes for these traits have been identified.

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 1998 | | 10,000 |
| Request for 1999 | | 13,000 |
| | Salaries | 8,000 |
| | Supplies | 4,000 |
| | Travel | 1,000 |

See accompanying progress report for more details of what was accomplished in 1998. As in the past this proposal will be submitted to the Oregon Raspberry and Blackberry Commission and the B.C. Raspberry Council for funding. In the past all three grower groups have participated in the funding of this project.

Post doctorate funds have been made available from the USDA-ARS to support the work on pollen transmission of RBDV. Therefore, I will not be submitting a proposal to the commissions to continue funding that part of the RBDV work.

**Project No:** New

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

**Personnel:** Chaim Kempler and Hugh Daubeny
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P.O. Box 1000, Agassiz, B.C., V0M 1A0.
Tel.: 604-796-2221 ext: 224, Fax: 604-796-0359, Internet: KemplerC@em.agr.ca

**Reporting Period: 1998**

**Accomplishments:** In 1998, about 3,500 seedlings from the 1996 crosses were screened for aphid resistance. Of those, 2,100 were found resistant and planted in the field for evaluation. Resistance to aphids will control the transmission of Raspberry Mosaic Virus complex (RMVC). Eight new selections were made among the 1993 crosses. They will be propagated and planted for further evaluation. We established new replicated planting with thirty clones. The 1993, 1994, 1995 and 1996 replicated plantings were evaluated during the 1998 harvest season. Data on fruit size, harvest season, post-harvest fruit rot, fruit firmness, Brix, pH and percent citric acid are presented in tables 1-5.

**Notes on cultivars and potential new cultivars:**

**Qualicum** - Recommended for trials. Fruit is large, firm and well adapted for fresh market and long distance shipping. Late reports show that it is suitable for mechanical harvesting and acceptable for processing. It shows excellent winter hardiness.

**Malahat** - Early ripening variety recommended for trials. It produces large, attractive, firm fruit that is up to a week earlier than any other recommended variety. Fruit is most suitable for the fresh market where early production and good quality are important. Plants are susceptible to root rot. Canes have small spines over most of the cane surface. Laterals are short. Fruit is very easy to harvest.

**Kitsilano (BC85-18-16)** - A newly named selection that is late ripening, fresh market type with attractive, medium size, glossy fruit. It produces high yields of firm bright, non darkening fruit with fine drupelets. Because of its size it is less likely to collapse compared with Tulameen. It has a lower susceptibility to fruit rot than other varieties. In greenhouse trials it was relatively susceptible to root rot.

**BC86-6-15** - Likely will not be named because it is very susceptible to root rot. It should be planted **only** on well-drained soil that is free of root rot. This selection produces high yields of early dark fruit that maintains good fruit size, has high soluble solids content and is very suitable for processing. The fruit releases easily during harvesting and has excellent quality when machine harvested.

**BC89-2-89** - A late fresh market selection from a cross between Comox and the Scottish variety75 Glan Ample. It produced high yields of large fruit. This selection will fruit later than any other recommended variety. Fruit is larger than Tulameen, light in colour, with large drupelets. The plant is very vigorous, with strong canes and long upright laterals.

**BC89-33-84** - Selected from a cross between Tulameen and BC82. A mid season processing and fresh market type that produces attractive dark berries with some resistance to fruit rot. Fruit is easy to harvest and most likely will machine harvest well.

**BC90-4-48** - A *Rubus strigosus* derivative that produced the highest yield in the test plots for the last three years. This year it showed lots of crumbly fruit due to infection to RBDV. Under a high infection presser this selection became infected after four years in the field and it is possible that this selection is more susceptible to RBDV infection. This selection is no longer recommended.

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

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

**Results:**

Table 1. Yield and harvest season of Meeker and advanced raspberry selections harvested in 1998.

| Clone | Yield (kg/plant) | Late yield (kg/plant) | Fruit Rot (%) | First Harvest (date) | 50% Harvest (date) | Harvest Duration (days) |
|---|---|---|---|---|---|---|
| Meeker | 2.14 | .38 | 24.2 | 3 July | 16 July | 37 |
| 89-2-89 | 1.94 | .63 | 30.8 | 3 July | 15 July | 33 |
| 90-4-48 | 1.81 | 1.19 | 27.3 | 3 July | 18 July | 43 |
| 90-6-2 | 2.74 | 1.09 | 29.2 | 3 July | 15 July | 46 |

Late harvest= yield after Mid July.

Table 2. Fruit size of raspberry cultivars and selection, harvest season 1998

| Clone | Fruit size (g) |
|---|---|
| 84-12-22 | 3.0 |
| 85-18-16 (Kitsilano) | 3.0 |
| 86-6-15 | 3.7 |
| 86-7-21 | 3.4 |
| 87-2-49 | 4.4 |
| 87-3-37 | 3.7 |
| 87-5-1 | 3.7 |
| 87-9-6 | 3.5 |
| 87-12-11 | 3.4 |
| 87-12-32 | 3.6 |
| 87-14-16 | 3.8 |
| 87-14-20 | 4.5 |
| 87-14-35 | 4.1 |
| 87-18-7 | 3.9 |
| 89-2-46 | 3.9 |
| 89-2-89 | 4.9 |
| 89-6-12 | 3.7 |
| 89-6-13 | 3.7 |
| 89-25-60 | 3.4 |
| 89-33-84 | 3.7 |
| 89-34-41 | 3.2 |
| 90-1-42 | 3.2 |
| 90-2-45 | 3.3 |
| 90-2-57 | 3.0 |
| 90-4-23 | 3.7 |
| 90-4-48 | 2.6 |
| 90-5-26 | 2.9 |
| 90-5-30 | 4.4 |
| 90-6-2 | 4.8 |
| 90-8-11 | 4.1 |
| 90-8-20 | 4.9 |
| 90-11-44 | 3.0 |
| 90-12-50 | 3.2 |
| 90-17-3 | 1.6 |
| 90-17-13 | 2.4 |
| 90-17-45 | 2.0 |
| 90-18-18 | 2.5 |
| 90-19-11 | 1.9 |
| 90-19-34 | 2.5 |
| 90-20-20 | 1.8 |
| 90-20-34 | 2.7 |

| Clone | Fruit Size (g) |
|---|---|
| Algonuin | 2.9 |
| Bababerry | 4.0 |
| Balder | 3.0 |
| Beskid | 3.1 |
| Chilcotin | 3.3 |
| Chilliwack | 3.0 |
| Comox | 3.5 |
| Glan Ample | 4.8 |
| Glan Clova | 3.7 |
| Glan Magna | 4.8 |
| Glan Moy | 4.7 |
| Glan Prosen | 3.6 |
| Glan Rosa | 3.0 |
| Glan Shee | 4.8 |
| Haida | 2.8 |
| Himbo Queen | 4.0 |
| Malahat | 4.0 |
| Meeker | 3.4 |
| NZ-24-WD-10 | 4.8 |
| NZ-24-WF-9 | 2.7 |
| Newburgh | 2.7 |
| Nootka | 3.0 |
| P86141 | 3.5 |
| Qualicum | 4.1 |
| SX84-34 | 3.4 |
| Skeena | 3.2 |
| Tulameen | 4.1 |
| Vene | 3.0 |
| WSU908 | 3.2 |
| **LSD 5%** | **0.8** |

Least significant difference(LSD) used to separate means.

Table 3. Susceptibility of red raspberry varieties and selection to fruit rot (*Botrytis cinerea*) in the 1998 fruiting season.

| Clone | Botrytis-incited fruit rot after 48 h (%) |
|---|---|
| **85-18-16 (Kitsilano)** | 32.2 bc |
| **86-6-15** | 24.4 c |
| **87-3-37** | 31.1 bc |
| **87-5-1** | 32.8 bc |
| **87-14-20** | 50.6 ab |
| **89-2-46** | 37.8 bc |
| **89-2-89** | 33.9 bc |
| **89-33-84** | 22.8 c |
| **89-34-41** | 30.0 bc |
| **90-4-48** | 35.0 bc |
| **90-5-30** | 48.3 ab |
| **90-6-2** | 29.4 bc |
| **90-8-20** | 49.5 ab |
| **Chilliwack** | 28.9 bc |
| **Malahat** | 29.4 bc |
| **Meeker** | 41.7 abc |
| **Qualicum** | 30.0 bc |
| **Tulameen** | 32.2 bc |
| **Vene** | 58.9 a |
| **NZ-87-24-WD10** | 51.5 ab |
| **NZ-87-24-WF9** | 35.0 bc |

Means from three test. In every test a cultivar was represented by 12 fruit from each of four replications.

Table 4. Fruit traits of red raspberry varieties and selections tested on fruit harvested in 1997 and 1998.



| Clone | Firmness (N) | Soluble Solids conc. (%) | pH | Titratable acid (% Citric) |
|---|---|---|---|---|
| 85-18-16 (Kitsilano) | 2.3 | 8.14 I-k | 3.23 f-I | 2.18 b |
| 86-6-15 | 2.2 | 9.19 c-j | 3.31 d-g | 1.89 b-f |
| 87-14-16 | 1.6 | 11.63 a | 3.23 f-I | 2.08 b-e |
| 87-14-20 | 1.6 | 9.20 c-j | 3.36 de | 1.52 g |
| 87-18-7 | 1.9 | 10.25 b-f | 3.30 d-g | 1.64 f-g |
| 87-2-49 | 2.1 | 7.48 k | 3.21 f-I | 2.14 bc |
| 87-5-1 | 1.5 | 8.40 h-k | 3.18 h-j | 2.06 b-e |
| 89-2-89 | 2.0 | 8.77 f-k | 3.31 d-g | 1.63 fg |
| 89-25-60 | - | 8.83 e-k | 3.49 b | 1.27 h |
| 89-33-84 | 2.7 | 10.37 b-d | 3.14 ij | 2.16 bc |
| 89-34-41 | 1.9 | 8.99 d-j | 3.52 ab | 1.31 h |
| 89-6-12 | 2.3 | 8.30 I-k | 3.21 f-I | 1.93 b-f |
| 89-6-13 | - | 9.13 c-j | 3.24 f-I | 1.95 b-f |
| 90-2-45 | - | 9.06 d-j | 3.32 d-f | 1.96 b-f |
| 90-4-23 | 2.1 | 10.57 b-c | 3.31 d-g | 1.87 b-f |
| 90-4-48 | 1.7 | 10.31 b-e | 3.32 d-f | 1.77 d-g |
| 90-5-30 | 2.2 | 9.82 b-h | 3.58 a | 1.17 h |
| 90-6-2 | 2.1 | 8.13 I-k | 3.29 d-h | 1.81 c-g |
| 90-8-11 | 2.2 | 9.15 c-j | 3.24 f-I | 1.67 fg |
| 90-8-20 | - | 10.17 b-g | 3.20 g-I | 2.09 b-d |
| Autumn Bliss | - | 7.80 j-k | 3.45 bc | 1.74 d-g |
| Chilliwack | 2.3 | 10.12 b-g | 3.26 e-h | 1.96 b-f |
| Malahat | 1.9 | 9.93 b-g | 3.22 f-I | 1.78 d-g |
| Meeker | 1.4 | 9.85 b-h | 3.38 cd | 1.73 e-g |
| NZ-24-WD-10 | 1.8 | 8.70 g-k | 3.24 f-I | 1.62 fg |
| NZ-24-WF-9 | 1.8 | 9.58 b-I | 3.27 e-h | 1.91 b-f |
| Qualicum | 1.8 | 9.88 b-g | 3.18 h-j | 2.05 b-e |
| Tulameen | 2.1 | 10.74 b | 3.10 j | 2.44 a |

**Project No.:** **New**

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

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

**Personnel:** Chaim Kemper and Hugh Daubney
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**Justification:**
The Agriculture and Agri-Food Canada (AAFC) breeding program supports the berry industry throughout the PNW and produces varieties that enhance production. Of particular importance is disease and pest resistance such as resistance to fruit rot, root rot, raspberry mosaic virus (RMV) and raspberry bushy dwarf virus (RBDV).

The RMV complex is a limiting factor in raspberry production and can be controlled by resistance to the aphid vector. Reaction to the aphid vector *(Amphorophora agathonica)* of the RMV is used by the PARC program as a primary screen in the seedling stage. All the cultivars that are released from this program are resistant to the common biotype of *A. agathonica*. A resistance-breaking biotype of *A. agathonica* has been found in North America and this has complicated the screening procedure. There is a need for genes that are resistant to resistance-breaking aphid biotype, or more universal resistance genes to RMV need to be identified. Raspberry bushy dwarf virus (RBDV) causes symptoms that adversely affect fruiting and growth in susceptible raspberry cultivars and selections. The combination of RBDV with raspberry mosaic virus (RMV) has been shown to be particularly detrimental to growth and fruiting. The common strain of the RBDV virus has been controlled by breeding for resistant cultivars of cultivars released from the program in the past, Haida is resistant to RBDV and Nootka, although not known to be resistant, never tested positive to RBDV and likely has very good tolerance and does not get infected with the virus.

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

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

The PARC breeding program has emphasis on broadening the genetic base by using parents that were derived from various species. Germplasm from other breeding programs around the world is used. This germplasm is tested and used to incorporate desirable traits. Also, a wide range of wild species is used. The last three cultivars released 'Tulameen', 'Qualicum' and 'Malahat', have the black raspberry, *Rubus occidentalis* L., in their derivation. In addition, 'Malahat' has *R. phoenicolasius* Maxim. Each potential cultivar that is now in growers' trials have *R. occidentalis* in their derivation. As well, BC 85-18-16 has *R. crataegifolius* in its derivation, BC 90-6-2 has the 'Dalhousie Lake' selection of *R. strigosus* Maxim. in their derivation.

**Objectives:**

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

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

**Procedures:**

*Experimental Details:*

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

Continue evaluation of all selections in the test plots at the Abbotsford Sub Station. The evaluation in the test plots will include yield and fruit quality determinations and reactions to various pests and diseases, including fruit rot, cane disorders, aphids (which vector the mosaic virus complex) and raspberry bushy dwarf virus, root rot (*Phytophthora fragariae)*. Any winter damage will be recorded relative to the standard cultivars, Meeker, Chilliwack and Tulameen.

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

*Activities:*

- 1999 crossing blocks -continue backcross on the F1 to F3 rot root resistance selections.
- Evaluation of seedling population (approx. 7,000)
- Establish advanced replicated trials to assess advanced selections suitable for processing and machine harvest.
- Establish advanced replicated trials to assess advanced red raspberry selections.
- Evaluation and propagation of advanced selections.
- Giving cultivar status to selection BC85-18-17.
- Supervise distribution of advanced selections to North American propagators, growers and subsequently monitor their performance.

**Anticipated Benefits and Information Transfer:**
The results of the evaluations will be directly available to the red raspberry industry in North America. In the coming year the evaluations will help determine if selections like BC87-14-20, BC89-2-89, BC89-6-12, BC89-32-69, BC89-33-84, BC89-33-84, BC90-1-42, BC90-2-45, BC90-4-23, BC90-5-26, BC90-6-2, BC90-11-44 and others are commercially suitable.

**Budget:**
**Amount allocated by Commission fo FY 1998-99:** US$ 5,000.

The WRRC contribution could be matched by Agriculture and Agri-Food Canada Matching Investment Initiative (MII) fund with up to CD$ 7,500.

*Resource commitments* (CD$): (for each year between April 1999- March 2002):

| | |
|---|---|
| Research assistance | $ 18,200 |
| Summer students (4 x $7,500) | $ 30,000 |
| Land preparation (fertilizer, field fumigation, etc.) | $ 5,000 |
| O&M (drip irrigation, trellis, etc.) | $ 4,800 |
| Travel | $ 2,000 |
| **Total** | **$ 60,000** |

**Other Support of project:**
Lower Mainland Horticultural Improvement Association
B.C. Raspberry Growers Association
North American Bramble Growers Association
Oregon Raspberry & Blackberry Commission

**Project No:** New

**Title:** Caneburning and Weed Control in Red Raspberries

**Year Initiated:** 1999-00 **Current Year:** 1999-00 **Terminating Year:** 2001-02

**Personnel:**

Timothy W. Miller, Extension Weed Scientist, WSUREU, Mount Vernon
Stephen F. Klauer, Chuhe Chen, Research Associates, WSUREU, Vancouver
J. Scott Cameron, Director & Ass't Dean, WSUREU-Vancouver
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**Justification:**

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

This weed control aspect of caneburning herbicides used in raspberries should not be overlooked. In particular, control of the perennial weed species becomes more important the longer raspberry blocks are left in production. Horsetail (*Equisetum* spp.), quackgrass *(Elytrigia repens)*, broadleaf dock (*Rumex obtusifolius*), Canada thistle (*Cirsium arvense*), dandelion (*Taraxacum officinale*), hedge bindweed

(*Calystegia sepium*), and common catsear (*Hypochaeris radicata*) have long been weedy in western Washington. A newly introduced perennial species with tremendous weedy potential is yellow nutsedge (*Cyperus esculentus*), which is listed as one of the world's worst weeds. If not controlled, these perennial weeds can be a major factor in reducing the longevity of raspberry plantings.

**Objectives:**

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

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

**Procedures:**

1. Long-term plots will be established at WSU-Vancouver to study the effects of Goal (oxyfluorfen), Aim (carfentrazone), and Enquik (monocarbamide dihydrogensulfate) used to control primocane growth of raspberry. Products will be applied at recommended rates and timings each spring for three consecutive growing seasons. Effect of the products on primocane suppression, weed control, and berry yield will be evaluated. Yield estimations will be accomplished by removing and analyzing four random canes per plot just before harvest. Plots will be 10 feet in length and contain three hills trained in a modified hedgerow. During each week of harvest, plots will be partially harvested in a random manner and the weight of 50 berries recorded. Yield potential will be estimated on both a per acre and per cane basis. At the end of the season, primocane numbers per plot will be recorded. Annual yield component analysis will demonstrate alterations in plant reproductive effort resulting from caneburning programs during the given year, as well as over time.

Caneburning studies will also be conducted on grower raspberry fields near Lynden, WA. Products of interest are Goal and Aim. New products of interest are Scythe (pelargonic acid) and Tough (pyridate). Tank mixtures tested in 1998 are Milestone + Gramoxone (azafenidin + paraquat), Visor (thiazopyr) + Goal, and Scythe + Goal will tested again in 1999. All products will be applied to established raspberry plants when primocanes are 4 to 6 inches in height. Primocane suppression and regrowth, weed control, and berry yield resulting from caneburning treatments will be evaluated. Yield will be estimated by weekly

berry picking from a 1-meter section within each 10-ft plot length through the harvest season. Total weight from the harvested sections and 50-berry weights will be recorded.

2. Perennial weed control studies will be conducted on grower raspberry fields near Mt. Vernon, WA. Fall weed control products of interest are Milestone (azafenidin) and Visor, and spring tank mixtures applied at caneburning are Milestone, Visor, Gramoxone, Goal, and Aim. Fall treatments will be applied to dormant, established raspberries; spring tank mixtures will be applied to established raspberry plants when primocanes are 4 to 6 inches in height. Primocane suppression and regrowth, weed control, and berry yield will be evaluated.

**Anticipated Benefits and Information Transfer:**

These studies will improve primocane suppression practices in raspberries by adding to the knowledge of growers when they make decisions regarding herbicide selection and application. Data from this experiment will be used to support new herbicide registrations in raspberries and to fine-tune existing labels. The data resulting from these studies will be disseminated through extension bulletins and during grower meetings sponsored by extension faculty and the agricultural industry.

**Budget:** Amount allocated by Commission for FY 1998-99: $10,000
S. Cameron and T. Miller (co-PIs), project 13C-3555-2783 terminated 1998-99.

| | Requested 1999-00 |
|---|---|
| Time-slip | $10,000 |
| Operations (goods & services) | 2,000 |
| Travel | |
| Projected Needs | 1,000 |
| Meetings | 0 |
| Other | 0 |
| Equipment | 0 |
| Employee Benefits (16%) | 1,600 |
| Total Request | $ 14,600 |

**NOTE:** The budget would be evenly split between Mt. Vernon and Vancouver.

**Other Support of Project:**

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

**Project No.:** New

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

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

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

**Justification:** Root rot caused by the soil-borne fungus *Phytophthora fragariae* var. *rubi* is the most serious root disease of red raspberry. When Ridomil was first tested, plantings could be restored to productivity because the fungicide protected the remaining healthy portions of plants and then allowed the plants to re-grow by protecting new root and cane growth. In recent trials at the WSU Research and Extension Unit-Vancouver, it has been difficult to even establish new plants in Ridomil treated soil. Other approaches to controlling this devastating disease must be explored. Research in New York State demonstrated that amending soil with high rates of gypsum before planting suppressed this disease. That research was repeated here in Washington and after the first year, the results look very promising. It appears that gypsum may be an added tool for an integrated control program. We want to find out if gypsum can be used in established plantings to achieve the same results. Raised beds formed with a bed shaper are initially 12-14 inches high but settle and erode to only 6-9 inches after just one year. Some growers re-build beds by throwing soil from the alleyway up around the base of plants using a disc or similar piece of equipment. Other growers have created raised beds or ridges from flat plantings by the same technique. As new primocanes push up through the added layer of soil roots grow from underground portion of those canes into that layer. If gypsum could be incorporated in to that layer of soil, those new roots might be protected from the pathogen.

**Objectives:**

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

2. To determine if re-plants can be protected by gypsum when it is mixed with soil used to re-build existing raised beds before planting.

**Procedures:** Experiment A. In a planting that was established on raised beds in spring 1997, agricultural gypsum will be mixed with the soil in the alleyway before it is thrown up around existing plants to restore the raised bed to is original height. Approximately six inches of soil will be added to the raised bed in fall 1998. The control treatment will

**Procedures:** A field trial will be established in a commercial field in either Skagit or Whatcom County where the disease was severe in 1998. Test materials will be applied with an over-the-row boom sprayer. Each treatment will be replicated four times and individual plots will be 25-30 feet long (one post length). Several new (unregistered) fungicides will be tested. For comparison, the trial will also include standard fungicides and an untreated check.

On three dates during the harvest period lateral and fruit samples will be collected from every plot to determine the incidence of fruit rot. Three different tests will be used to evaluate the various treatments. On each harvest date fruiting laterals will be collected and each fruiting position scored to determine percent rot at that date. Healthy fully ripe berries will be picked by hand and then incubated in a moist chamber to determine rot incidence. A second sample of berries will be picked at the fresh market stage of ripeness. These berries will be fully colored but pink and they will be much firmer than berries that are fully ripe. Berries harvested at this stage continue to ripen after being harvested. These berries will be placed in clear plastic clamshell packs and held for 6 days under conditions thought to mimic those experienced during shipment to distant markets. Percent mold is assessed on day 6. Color development will be monitored with a Minolta color meter to see it the treatments influence color development.

**Anticipated Benefits and Information Transfer:** We expect to be able to identify new fungicides that will control this serious disease. Efficacy data from this trial will be used to help support registration requests to EPA. Such request will be made by the manufacturer or through the IR-4 Program for registration of pesticides on minor crops.

The results of this study 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 when and where appropriate.

be to use soil without gypsum. The two treatments will be repeated annually to maintain the height of the raised beds at 12 inches. Root rots severity (percent wilted primocanes, fruiting cane collapse and plant survival) will be assessed each growing season as will plant growth (number and length of healthy primocanes, etc.) and yield. As part of the integrated disease control program used on the entire planting, all plots will be treated with Ridomil and Aliette according to label directions.

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

**Anticipated Benefits and Information Transfer:**
*Benefits*: Controlling this serious root rot will require an integrated approach. Several of the approaches are best implemented when a new field is planted. Remedial treatment(s) for established plantings is more difficult, but the growth habit of the red raspberry plant appears to allow for some flexibility. The root system of the plant can be moved upwards in the soil profile by mounding soil around the base of plants. If high rates of gypsum can be incorporated into the soil used to create or maintain raised beds then it may be possible to protect new roots that grow in the bed. Even at high rates, gypsum is relatively inexpensive and because it dissolves slowly, it most likely will not have to be applied every year.
*Information/Technology Transfer:*
Information from this project will be disseminated at local and regional grower's meetings. It will be incorporated into WSU Cooperative Extension publications where appropriate. The results will be combined with results from other research for publication in scientific journals.

**Budget:**

| | |
|---|---|
| Request for FY 1999-2000 | |
| Timeslip labor | $1,300 |
| Operations (goods and services) | 700 |
| Travel | |
| Projected needs | 200 |
| Meetings | 42 |
| Equipment | 0 |
| Employee benefits | 208 |
| Total | $2,450 |

**Project No.:** New

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

**Year initiated:** 1999 **Current year:** 1999 **Terminating year:** 2000

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

**Justification:** Red raspberry producers sustained unacceptable losses due to gray mold fruit rot in both 1997 and 1998. The losses occurred despite the use of registered fungicides. Growers in Whatcom and Skagit Counties were especially hard hit. Much of the situation can be attributed to weather condition that favored the fungus at the most critical periods. Widespread resistance to two of the principal fungicide groups, benzimidazole (Benlate) and dicarboximide (Ronilan and Rovral) also played a pivotal role. Ripening berries rotted before they could be harvested. Mold present on harvested fruit either rendered it unsalable or acceptable only at a much lower grade and in most instances that grade was juice stock. Several growers who had their crop pick by hand with the expectation of selling the fruit on the fresh market were forced to sell the berries for processing.

The last time gray mold damage was this great was in the early 1980's just before the introduction of Ronilan and Rovral. These two material were extremely effective against *Botrytis cinerea* but less than a decade later widespread resistance was reported in the Willamette Valley and suspected in Washington red raspberry field as well. Most of the isolates of the fungus collected in 1998 from red raspberry fields in Whatcom and Skagit Counties were resistant to Benlate, Ronilan and Rovral. To date we have not detected resistance to Captan although it has been reported from British Columbia. Apparently, disease pressure was so high that it overcame the ability of Captan to control the disease.

**Objectives:**

1. To evaluate new fungicides for their ability to control gray mold fruit rot caused by the fungus *Botrytis cinerea*.

2. Evaluate the various treatments for control of cane diseases such as spur blight.

**Budget:**

| | |
|---|---|
| Request for FY1998-99 | |
| Timeslip labor | 1,900 |
| Operations (goods and services) | 745 |
| Equipment (plot sprayer*) | 4,000 |
| Travel | |
| Projected needs | 350 |
| Meetings | 100 |
| Employee benefits | 305 |
| Total | $7,400 |

* The plot sprayer will be similar to the one Dr. Lynell Tanigoshi designed and had built by Rears Manufacturing. The sprayer will have six small (about 5 gallons) tank allowing six chemicals to be mixed at one time. A series of valves are used to switch from one tank to the next. Small volumes of spray solution can be used. The sprayer will have an over-the-row boom so applications will be very similar to those made by growers.

**Other Support of Project:** A grant-in-aid request will be submitted to each company that has an experimental fungicide in the trial. Funds from this source will be used to help purchase the plot sprayer. In addition, a grant request will be submitted to the Washington State Pesticide Registration Commission (WSPRC) for funds to reimburse the cooperating grower for fruit that must be destroyed because it has been treated with experimental chemicals. The WSPRC requests matching support for projects it considers. Any funds from the Washington Red Raspberry Commission with be used to satisfy that match. In-kind contributions (insect and weed control, harvesting, etc.) from the cooperating grower can also be used for the match.