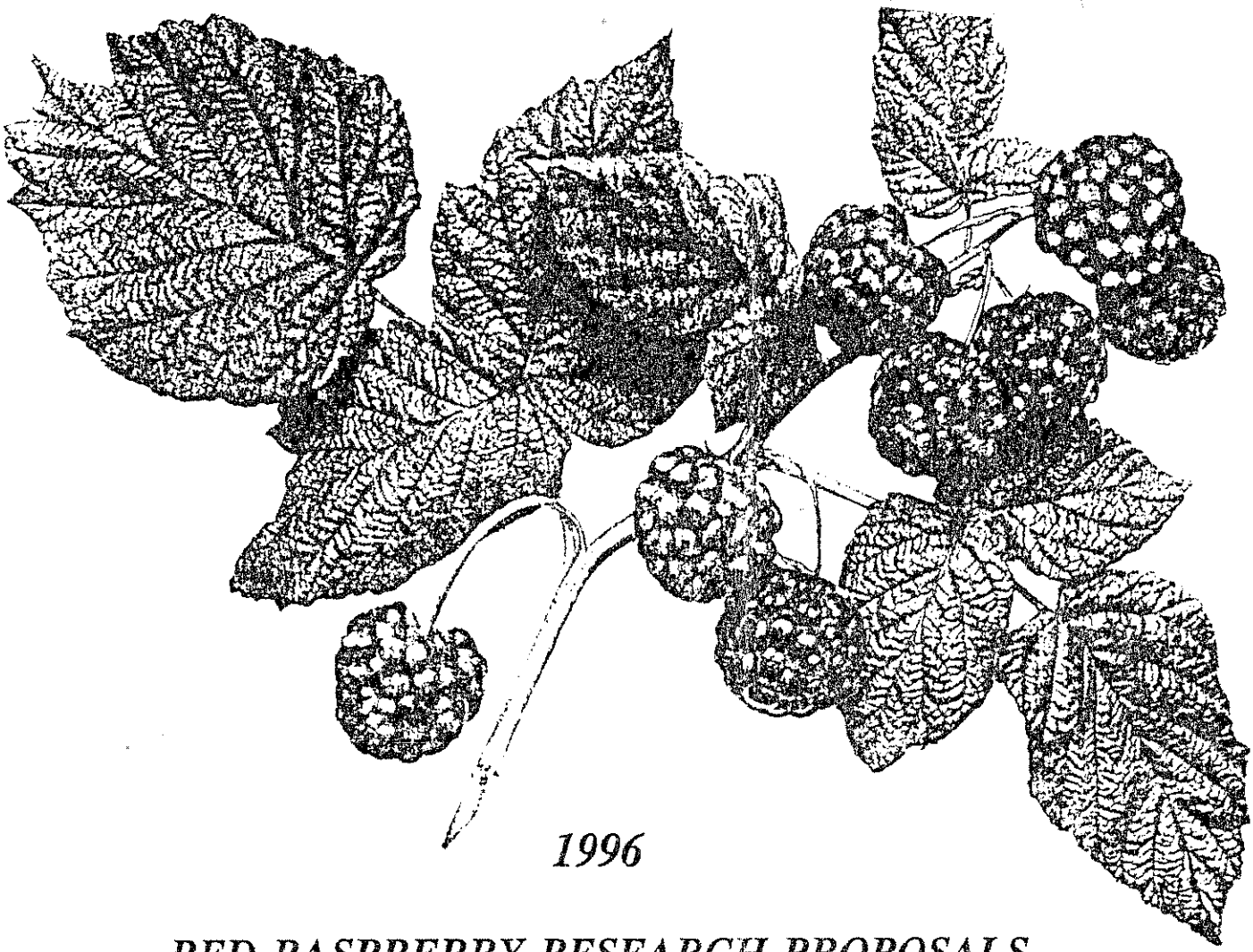

1996

RED RASPBERRY RESEARCH PROPOSALS

1995 PROGRESS REPORTS

to the

WASHINGTON STATE RED RASPBERRY COMMISSION

and

NORTHWEST RED RASPBERRY GROWERS ASSOCIATION

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1995-96

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A:RaspComm.96/cm
11/95

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Summary
Budget Requests

On-Going Projects

Project No.	Short Title	Lead Scientist	Amount Requested
13C-3755-5641	Raspberry Breeding	Moore	$ 27,500
13C-3755-8640	Advance Testing	Moore	-0-
13C-3543-4958	Control of Root Weevils	Shanks	-0-
13C-3543-7960	Mgmt. of Spider Mites	Tanigoshi	-0-
13C-3555-2783 Part A	Advance Testing-Caneburning	Cameron	12,922
13C-3555-2783 Part B	Caneburning Mgmt.	Cameron	-0-
13C-3555-4883	Mites/Plant Physiology	Cameron	-0-
13C-3555-5784	Yield Efficiency	Cameron	10,820
13C-3761-5718	Resistance to Root Rot	Bristow	948
13C-3761-6718	Raised Beds	Bristow	1,875
13C-3761-7718	Yellow Rust Fungus	Bristow	-0-
13C-3755-3775	Cold Hardiness	Hummel	4,605
--- ---- ----	Raspberry Breeding-B.C.	Kempler	-0-
--- ---- ----	Machine Harvest	Strik	2,400
--- ---- ----	Transformation of Raspberry	Martin	2,000
13C-3761-6784	Cane Dieback Disease	Bristow	580
--- ---- ----	Resistance to Root Weevils	Vrain	6,000
--- ---- ----	Equipment/Virus Elimination	Finn	4,080

New Projects

Short Title	Lead Scientist	Amount Requested
Twospotted Spider Mite Resistance	Tanigoshi	$9,500
Evaluation/Nitrogen Levels	Miles	5,240
Advanced Testing/Vancouver	Moore	2,984
Advanced Testing/Mt. Vernon	Moore	7,521
Fungicide Control/Phytophthora	Bristow	6,330
Suppress Root Weevils	Booth	8,532
Control of Root Weevil Larvae	MacConnell	1,560
Management of Spider Mites	MacConnell	1,994
Northern Washington Research	Tanigoshi	31,080
Chemotherapy Strategies	Martin	4,000
Machine Harvest - B.C.	Kempler	5,000

A:Raspbook.96/cm 11/95

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: 1995

Accomplishments: In 1995, 67 crosses were made. Thirty eight crosses were directed toward cultivar development, 7 for germplasm expansion and 22 to study spider mite resistance. Seedlings from these crosses will be planted in 1996 and evaluated in 1998 and 1999. Over 6,500 seedlings were planted at Puyallup. About 2,000 seedlings were planted at WSU-Vancouver for studies on mite resistance and by the Oregon breeding program. Thirty eight clones were planted in replicated yield trials at Puyallup. Twenty eight selections were made among seedlings planted in 1992 and 1993. The largest factor in the seedling field was root rot. Fifteen selections were made for possible cultivar development with the remaining 13 selections for breeding purposes.

The 1993 test planting was harvested for the first time in 1995. Twelve of the 13 highest yielding clones in replicated plots were WSU selections (Table 1). The highest yielding selection was WSU 1098 and 'Comox' was the highest yielding cultivar. BC 86-7-21 was the highest yielding clone but was present only in a single plot.

The 1992 test planting was harvested for the second time in 1995 (Table 2). Even though it has been treated with Ridomil in both spring and fall, there was widespread root rot. 'Glen Ample' was the highest yielding. 'Meeker', WSU 1067, ORUS 576-47 and ORUS 2078 were the next highest yielding, but did not differ significantly from 'Glen Ample'.

The 1991 test planting was harvested for the third time in 1995 (Table 3). The relationship between the first harvest season and the second harvest season has been weak for most of the raspberry test plantings for which this has been examined over the past few years. The correlation between the first harvest season and the second was r^2 = 0.02, and 0.28 between the second and the third. WSU 992 was the highest yielding clone over the three years, with a total of 23.9 t/a.

Plants have been obtained of WSU 991 that do not appear to have the dsRNA bands. Plants will be held over winter and retested after regrowth prior to release.

Publications:

Moore, P.P. 1995. What's New in the Search for the Perfect Berry. West. Wash. Hort. Assoc. 85:88-91.

Shanks, C.H.,Jr and P.P. Moore. Resistance of Red Raspberry and other *Rubus* species to Twospotted Spider Mite (Acari:Tetranychidae). J. Econ. Entomol. In Review.

Presentations:

November, 1994. Display of strawberries and raspberries. Northwest Center for Small Fruit Research. Portland, OR.

January, 1995. Display of strawberries and raspberries. Western Wash. Hort. Assoc. Tacoma, WA.

January, 1995. Display of strawberries and raspberries. Northwest Food Processors, Seattle, WA.

February, 1995. Progress in Strawberry and Raspberry Breeding at WSU. Oregon Hort. Soc., Portland, OR.

February, 1995. Display of raspberries. Oregon Raspberry and Blackberry Commission. Aurora, OR.

March, 1995. Evaluation of Raspberry Samples by Processors, Aurora, OR.

July, 1995. Raspberry Field Day. Puyallup, WA.

July, 1995. Raspberry Field Day. Mt. Vernon, WA.

August, 1995. Distinguishing Pacific Northwest Red Raspberry Cultivars using RAPD Markers. HortScience 30:833 (Abst.)

Table 1. 1995 harvest of 1993 planted raspberries, Puyallup, WA.

Clone	Yield (t/a)	Fruit Rot (%)	Fruit Weight (g)	Fruit Firmness (g)	Harvest Season 5%	50%	95%	Length
BC 86-7-21*	10.5	7	4.6	181	6/28	7/8	7/24	26
WSU 1098	8.7 a	15 c d	2.8 f	124 d	6/20 b - d	7/4 b - e	7/19 a b	29 a
WSU 1096	7.6 a b	23 b - d	3.0 e f	164 a - d	6/17 d e	7/1 c - g	7/15 c - e	28 a b
WSU 1081	7.5 a b	22 b - d	4.9 a	174 a b	6/19 b - d	7/2 b - f	7/16 b - e	26 a - d
WSU 1099**	7.1	12	3.9	134	6/21	7/6	7/22	32
WSU 1097	7.0 a - c	18 c d	3.5 c - f	130 c d	6/16 d - f	7/1 c - g	7/15 b - e	29 a
WSU 1082	6.3 a - d	23 b - d	4.1 a - e	168 a - c	6/19 b - d	7/1 c - g	7/12 d - h	24 a - d
WSU 1102**	6.2	14	3.5	186	6/19	7/5	7/17	29
COMOX	6.2 a - e	18 b - d	3.8 b - f	195 a	6/16 d e	7/2 b - f	7/14 c - f	27 a - c
WSU 1100	5.8 b - e	18 b - d	4.2 a - d	167 a - c	6/20 b - d	7/3 b - e	7/12 e - h	22 b - d
WSU 1091	5.8 b - e	16 c d	3.9 a - f	170 a - c	6/27 a	7/9 a	7/21 a	24 a - d
BC 85-18-16*	5.5	13	2.7	146	6/21	7/8	7/22	31
WSU 1080	5.3 b - f	22 b - d	4.1 a - e	153 a - d	6/19 b - d	7/2 b - f	7/15 b - e	26 a - d
WSU 1103	5.2 b - f	20 b - d	3.9 a - f	191 a	6/18 c - e	6/29 e - g	7/10 f - i	22 a - d
WSU 1090	5.2 b - f	25 a - c	4.9 a b	195 a	6/23 a - c	7/4 b - d	7/17 b - d	23 a - d
WSU 1095	4.5 c - f	11 d	4.3 a - c	187 a b	6/25 a b	7/6 a b	7/16 b - e	21 c d
BC 86-6-15*	4.5	11	4.6	214	6/17	7/1	7/11	24
WSU 1083	4.3 c - f	22 b - d	3.4 c - f	182 a b	6/10 f	6/27 g	7/9 g - i	29 a b
TULAMEEN	4.3 c - f	15 c d	3.4 c - f	158 a - d	6/20 b - d	7/5 b c	7/17 b c	27 a - d
WSU 1092	4.3 c - f	21 b - d	2.8 f	161 a - d	6/18 c d	6/30 c - g	7/13 c - g	24 a - d
WSU 968	4.2 c - f	16 c d	3.1 d - f	181 a b	6/18 c d	7/2 b - f	7/15 b - e	27 a - d
WSU 1087	4.0 d - f	31 a b	3.2 c - f	162 a - d	6/16 d - f	6/27 g	7/8 h i	22 a - d
WSU 1101	4.0 d - f	19 b - d	3.8 b - f	159 a - d	6/20 b - d	7/1 c - g	7/10 f - i	20 d
WSU 1094	4.0 d - f	21 b - d	3.1 e f	176 a b	6/18 c d	7/3 b - e	7/17 b c	29 a b
WSU 1084	3.9 d - f	18 b - d	3.5 c - f	169 a - c	6/14 d - f	7/2 b - f	7/13 c - g	29 a
BC 85-5-24*	3.9	20	3.3	174	6/18	6/30	7/11	23
MEEKER	3.7 d - f	24 a - c	3.1 e f	153 a - d	6/17 c - e	7/1 c - g	7/16 b - e	29 a b
WSU 1085	3.6 d - f	15 c d	3.8 c - f	173 a b	6/18 c d	6/30 d - g	7/10 f - i	22 b - d
WILLAMETTE	3.5 d - f	20 b - d	3.1 e f	149 b - d	6/16 d e	6/27 g	7/9 g - i	22 a - d
WSU 1086	3.4 e f	16 c d	3.7 c - f	160 a - d	6/19 b - d	6/28 f g	7/10 f - i	21 c d
WSU 1088	3.3 e f	36 a	3.6 c - f	147 b - d	6/11 e f	6/21 h	7/6 i	25 a - d
CHILLIWACK	2.5 f	16 c d	2.9 f	179 a b	6/19 b - d	7/2 b - f	7/13 c - f	24 a - d
Average	5.2	19	3.6	168	6/19	7/2	7/14	25

Means are averages of three 3 hill plots. Means within columns followed by the same letter are not significantly different using Duncan's Multiple Range Test, p=0.05. Only two plots were harvested for clones indicated by **, and one plot for the clone indicated by *. These clones were not included in the statistical analysis, and comparisons must be made cautiously.

Table 2. 1994-1995 harvest of 1992 planted raspberries, Puyallup, WA.

	Yield (t/a)			Fruit Rot (%)		Fruit Weight (g)		Fruit Firmness (g)		Harvest Season			
	1995	1994	Two Year Total	1995	1994	1995	1994	1995	1994	5%	50%	95%	Length
GLEN AMPLE	11.7 a	8.1 a	19.8 a	25 a - f	4 f	4.7 a	4.7 a	187 a b	242 a - c	6/20 c - h	7/1 f g	7/18 b - g	28 a - d
MEEKER	11.1 a b	7.4 a - c	18.5 a b	12 g - i	6 d - f	3.1 i - k	3.5 g - k	135 f - h	160 g - j	6/18 e - i	7/5 b - e	7/20 b - e	32 a
WSU 1067	9.1 a - d	7.3 a - c	16.4 a - c	18 d - i	7 c - f	3.5 e - j	3.7 e - i	143 e - h	139 h - j	6/25 a	7/3 d - f	7/20 b - f	24 c - e
ORUS 576-47	8.1 b - e	7.9 a b	16.0 a - d	15 f - i	3 f	3.4 e - j	4.4 a b	177 a - d	212 b - f	6/25 a b	7/7 b c	7/22 a - c	27 a - e
ORUS 2078	10.3 a - c	5.5 c - f	15.8 a - e	17 e - i	7 c - f	4.4 a - c	4.2 b - d	155 c - h	156 g - j	6/24 a - c	7/7 b	7/22 a b	28 a - d
WSU 1066	8.1 b - e	7.3 a - c	15.4 a - e	19 c - i	14 a	4.1 a - e	4.3 a - c	148 d - h	188 d - g	6/17 f - i	6/25 k	7/10 j - l	23 d e
WSU 1063*	5.9	9.5	15.3	20	7	3.4	4.0	170	216	6/19	6/30	7/12	23
WSU 1064	7.4 c - f	7.1 a - c	14.5 b - f	18 d - i	9 b - e	3.3 g - k	3.9 c - f	142 e - h	171 f - i	6/25 a	7/5 b - d	7/21 b - d	25 b - e
WSU 984	7.9 b - f	5.8 c - f	13.7 c - g	25 a - e	12 a b	3.9 c - h	4.0 b - e	161 a - h	221 a - e	6/20 b - g	7/3 d - f	7/20 b - d	30 a - c
WILLAMETTE	7.9 b - f	5.8 c - f	13.6 c - g	21 b - h	7 c - f	3.4 f - k	3.4 h - k	145 e - h	173 f - i	6/17 f - i	6/26 i - k	7/11 j - l	24 c - e
WSU 1068	6.3 d - f	7.1 a - c	13.5 c - h	30 a b	13 a	3.9 c - h	4.3 b c	139 e - h	178 e - i	6/15 h i	6/24 k	7/10 j - l	25 b - e
WSU 1071	8.5 a - e	4.8 d - f	13.3 c - h	21 b - g	9 b - e	4.0 b - f	3.9 c - g	148 d - h	120 j	6/18 d - i	6/29 g h	7/15 f - i	27 a - e
COMOX	7.5 c - f	5.8 c - f	13.3 c - h	23 a - f	7 c - f	3.9 c - h	4.0 b - e	166 a - f	224 a - d	6/17 f - i	7/1 f g	7/14 g - j	27 a - e
TULAMEEN	7.2 c - f	5.5 c - f	12.8 c - h	20 c - i	10 a - d	4.7 a b	3.9 c - f	191 a	169 f - i	6/18 f - i	7/1 f g	7/16 d - i	29 a - d
WSU 994**	7.8	4.6	12.4	25	11	4.6	4.9	168	158	6/17	6/30	7/16	29
WSU 988	7.8 b - f	4.5 d - f	12.3 c - h	28 a - c	14 a	4.0 c - h	4.0 b - f	131 h	183 d - h	6/17 f - i	6/29 g h	7/17 d - i	30 a - c
WSU 1007	5.9 d - f	6.0 b - e	11.9 c - h	31 a	6 c - f	3.8 c - i	3.8 d - h	169 a - e	259 a	6/19 d - i	7/3 d - f	7/20 b - d	31 a b
WSU 1065	7.0 c - f	4.8 d - f	11.8 c - h	20 c - i	10 a - c	4.2 a - d	3.3 i - l	146 e - h	141 h - j	6/18 f - i	6/29 g h	7/13 h - k	25 b - e
WSU 1069	5.4 d - f	6.3 a - d	11.7 c - h	23 a - f	5 e f	4.2 a - d	3.9 c - g	165 a - g	232 a - c	6/21 a - f	7/2 e f	7/17 c - h	27 a - e
CHILCOTIN	7.6 c - f	4.0 e f	11.6 c - h	17 e - i	14 a	3.6 d - i	3.6 f - j	159 b - h	141 h - j	6/16 f - i	6/29 g h	7/18 c - g	32 a
WSU 1072	5.9 d - f	5.7 c - f	11.5 d - h	20 c - i	6 c - f	2.4 l	2.7	147 d - h	144 g - j	6/17 f - i	6/27 h - j	7/12 i - l	26 a - e
WSU 968**	6.2	4.9	11.1	24	6	4.2	3.6	166	202	6/17	6/30	7/16	29
WSU 985	7.1 c - f	4.0 e f	11.1 e - h	22 a - f	12 a b	2.8 j - l	3.2 j - l	145 e - h	153 g - j	6/14 i	6/25 j k	7/9 k l	25 b - e
WSU 1061**	5.7	4.9	10.6	20	4	2.8	2.7	147	179	6/18	7/1	7/18	30
CHILLIWACK	5.7 d - f	4.6 d - f	10.3 f - h	17 e - i	6 e f	2.7 k l	3.1 k -	152 c - h	219 a - e	6/18 d - i	6/29 g h	7/11 j - l	23 d e
WSU 1009	5.9 d - f	4.2 e f	10.1 f - h	18 d - i	9 b - e	3.8 c - l	4.1 b - e	153 c - h	180 e - i	6/18 f - i	6/28 g - i	7/9 k l	21 e
WSU 1021	5.1 e f	4.8 d - f	9.9 f - h	11 h i	5 e f	3.1 i - k	3.9 c - g	180 a - c	252 a b	6/25 a b	7/10 a	7/26 a	31 a b
WSU 1073	5.3 e f	4.6 d - f	9.9 f - h	19 c - i	10 a - d	2.9 j - l	3.3 i - l	134 g h	137 i j	6/23 a - e	7/3 d - f	7/16 e - i	23 d e
ORUS 1836	5.5 d - f	4.0 f	9.4 g h	11 i	4 f	3.3 h - k	2.9 l	161 a - h	160 g - j	6/23 a - d	7/4 c - e	7/20 b - f	27 a - e
WSU 983**	4.5	4.6	9.1	27	7	3.4	3.4	149	199	6/18	6/26	7/12	24
WSU 991	4.3 f	4.5 d - f	8.8 h	28 a - d	14 a	4.0 b - g	4.0 b - f	162 a - h	205 c - f	6/15 g - i	6/25 j k	7/8 l	23 d e
WSU 1070**	4.2	4.5	8.7	29	13	3.8	3.8	137	118	6/17	6/25	7/7	20
WSU 1062**	3.4	4.3	7.6	32	4	2.9	4.2	141	201	6/19	6/30	7/17	28
Average	6.9	5.6	12.5	21	8	3.6	3.8	155	183	6/19	6/30	7/15	26

Means are averages of three 3 hill plots. Means within columns followed by the same letter are not significantly different using Duncan's Multiple Range Test, p=0.05. Only two plots were harvested for clones indicated by **, and one plot for the clone indicated by *. These clones were not included in the statistical analysis, and comparisons must be made cautiously.

Table 3. 1993-1995 harvest of 1991 planted raspberries, Puyallup, WA.

	Yield (t/a)				Fruit Rot (%)			Fruit Weight (g)			Fruit Firmness (g)			Harvest Season			
Clone	1995	1994	1993	Three year Total	1995	1994	1993	1995	1994	1993	1995	1994	1993	5%	50%	95%	length
WSU 992	8.9 A	8.2 A B	6.8 A	23.9 A	34 A	7 E	13 A	5.2 B C	5.5 B - D	4.1 B	151 C D	178 D E	95 D	6/11 D	7/9 A	7/23 A	42 A
WSU 1031	8.2 A B	7.9 A B	5.6 A - D	21.6 A B	23 A - D	7 D E	9 A - C	6.4 A	6.1 A B	5.0 A	170 B - D	175 E	92 D	6/19 A - D	7/1 C	7/16 C D	26 B C
WSU 1035	6.6 A - C	8.2 A B	6.6 A B	21.4 A B	26 A - D	7 E	6 C	4.0 D - F	4.7 E F	4.1 B C	173 B - D	214 A - D	111 B - D	6/20 A - C	7/2 C	7/17 B C	27 B
WSU 1037**	8.0	8.0	3.3	19.3	20	5	6	3.6	3.5	4.0	155	132	125	6/17	6/28	7/20	34
Qualicum	6.3 A - C	7.8 A B	5.0 A - D	19.2 A - C	22 A - D	6 E	7 C	4.9 B - D	5.4 C - E	4.4 B	187 A B	235 A	130 B	6/22 A - C	7/3 C	7/17 B C	25 B C
WSU 1033	5.7 B C	9.2 A	3.2 E F	18.0 B C	23 A - D	8 D E	5 C	4.6 B - E	4.8 E F	4.3 B	179 B - D	174 E	100 C D	6/15 C D	6/23 F	7/7 F - H	22 B C
WSU 1032	6.4 A - C	8.4 A B	2.9 E F	17.7 B C	14 D	4 E	6 C	3.4 F	4.0 G	3.6 C D	148 D	231 A B	101 C D	6/24 A B	7/6 B	7/19 B C	25 B C
WSU 1040	6.6 A - C	7.1 A - C	3.7 D - F	17.5 B C	29 A B	25 A	12 A B	5.3 B	6.7 A	5.2 A	218 A	227 A - C	188 A	6/15 C D	6/24 E F	7/5 H	21 B C
WSU 1041	4.8 C	6.4 B - D	6.1 A - C	17.3 B C	23 A - D	12 C D	13 A B	4.3 D - F	5.0 D E	4.4 B	191 A B	195 B - E	137 B	6/14 C D	6/22 F	7/3 H	20 B C
WSU 1039	5.4 B C	7.3 A B	4.7 B - E	17.3 B C	28 A - C	15 B C	8 A - C	5.2 B C	6.1 A B	4.4 B	183 B C	196 B - E	112 B - D	6/17 B - D	6/27 D	7/10 E F	23 B C
Willamette	6.4 A - C	6.6 B - D	4.3 C - F	17.3 B C	16 C D	5 E	7 C	3.7 E F	4.0 G	3.6 C D	165 B - D	190 C - E	124 B C	6/16 B - D	6/26 D E	7/12 D E	26 B C
WSU 1046**	6.4	5.4	4.7	16.5	23	7	3	4.3	4.2	3.9	221	209	125	6/21	7/1	7/16	26
WSU 1045	5.1 C	5.2 C D	5.4 A - D	15.7 C	21 B - D	12 C D	7 C	4.4 C - E	5.1 D E	4.4 B	150 C D	242 A	129 B	6/26 A	7/6 B	7/21 A B	25 B C
WSU 1044	5.0 C	5.0 D	5.2 A - D	15.2 C	16 C D	13 C	7 C	3.9 E F	4.4 F G	3.3 D	169 B - D	183 D E	124 B C	6/15 C D	6/22 F	7/3 H	18 C
WSU 991	5.7 B C	6.5 B - D	2.7 F	14.9 C	27 A - C	17 B	8 B C	5.4 B	5.8 B C	4.4 B	192 A B	222 A - C	130 B	6/15 C D	6/26 D E	7/9 E -	24 B C
Average	6.4	7.1	4.7	18.2	23	10	8	4.6	5.0	4.2	177	200	122	6/18	6/29	7/13	26

Means are averages of three 3 hill plots.

Means within columns followed by the same letter are not significantly different using Duncan's Multiple Range Test, p=0.05.

Only two plots were harvested for clones indicated by *. These clones were not included in the statistical analysis, and comparisons must be made cautiously.

PROJECT: 13C-3755-5641

TITLE: Red Raspberry Breeding, Genetics and Clone Evaluation

YEAR INITIATED:1994
CURRENT YEAR:1996
TERMINATING YEAR:1997

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

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

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

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

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

1. Crosses will be made for summer fruiting cultivar development. Clones identified by ongoing cold hardiness, disease and insect

resistance, fruit color, and drupelet number studies will be used as parents. Other important traits included are ease of fruit removal, fruit firmness, fruit size, fruit color, harvest season, fruit rot resistance, and growth form.

2. Sixty seven crosses were made in 1995. When possible, 100 seedlings will be planted for each cross. Selections will be made among these seedlings in 1998 and 1999.

3. Selections will be made among the seedlings planted in 1993 and 1994. Seedlings will be subjectively evaluated for yield, flavor, appearance, color, harvest season and growth form. For promising seedlings, fruit size, color, and firmness will be measured. Based on these observations, seedlings will be selected for propagation and further evaluation. Typically the best 1% or less of a seedling population will be selected.

4. Seedlings selected in 1995 (15 selections) will be propagated for testing in three replications of three hill plots and compared to standard cultivars. Thirteen other selections made in 1995 will be used for breeding only. Selections will be evaluated for yield, fruit size, fruit firmness, fruit rot, and harvest season as well as pest and disease resistance in 1997 and 1998.

5. The replicated planting established in 1993 will be harvested for the second time and the planting established in 1994 will be harvested for the first time in 1996.

6. After these evaluations, roots of promising selections will be dug from field plots at Puyallup winter 1996 and planted at Puyallup to produce field grown plants for distribution to growers in 1997. These plants will then be tested at additional research locations. At the same time, selections will be placed in trials with cooperating commercial growers for grower and processor evaluation.

7. The color of samples of fruit will be measured with a Minolta tristimulus colorimeter. The fruit weight and drupelet number per fruit will be determined for selected clones. These data will be used as part of the selection evaluation and as part of the basis of parent selection.

8. Fruit of promising selections will be frozen for display at grower

meetings and subjective evaluation of fruit quality.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

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

PROPOSED BUDGET: Support is requested for a portion of the project operations budget. Salaries for one WSU faculty member, two support staff, and $1,400 operating funds are provided by WSU for breeding work on BOTH raspberries and strawberries. This request will provide for funding for 0.25 of the salary and benefits of an Agricultural Research Technologist I. The remaining 0.35 FTE will be funded for 1996-97 by other commissions. The Ag. Res. Tech. I is being changed from 1.0 FTE to 0.6 FTE at her request. An additional 0.2 FTE for a graduate student assistantship is being requested to perform some of the Agr. Res. Tech. I responsibilities. The graduate student research project will be on raspberry also. Remaining funds would be used for hiring timeslip help for harvests and data collection, pots, soil, other supplies and travel. Travel would be to local grower meetings and to research plots.

	1994-95	1995-96
00 Salaries		
Agr. Res. Tech.		
0.40 FTE	$11,540	-
0.25 FTE	-	$7,076
Grad. Student 0.2 FTE	-	3,873
01 Timeslip labor	4,000	6,000
03 Service and supplies	2,143	4,016
04 Travel	400	400
06 Equipment	2,700	-
07 Benefits		
Ag. Res. Tech I	3,577	2,760
Grad. Student	-	2,415
Timeslip	640	960
Total	$25,000	$27,500

PROJECT NO.: 13C-3755-8640

TITLE: Advanced Testing of Washington State University Raspberry Selections

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

REPORTING PERIOD: 1995, project supporting testing at both Vancouver and Mt. Vernon is terminated. This project will continue as two separate proposals for testing at Vancouver and Mt Vernon.

ACCOMPLISHMENTS: Plantings of advanced selections were planted in 1992 at Vancouver, Puyallup, and Mt Vernon. Ten clones were harvested at all three locations in both 1994 and 1994. In 1994 and 1995, there were significant clone x location interactions for all harvest data except for fruit weight in 1995 (Table 1). In general, yields were highest at Mt. Vernon. A clone x location interaction means that not all clones behaved the same, WSU 988 performed very well at Vancouver, but was intermediate in Puyallup and Mt. Vernon. The performance of the clones at each location are given in Tables 2-4. All of the clones present at that location were included in each table not just the 10 clones present in all plantings. Glen Ample was the highest yielding clone and WSU 988 was the highest yielding selection across all locations. WSU 984 was the highest yielding clone at Mt. Vernon and WSU 988 was the highest yielding at Vancouver.

Twelve clones were planted in 1994 at Vancouver, Puyallup and Mt. Vernon. Six clones were WSU selections and one a BC selection. These clones will be harvested in 1996.

At Puyallup, WSU 968 was extremely susceptible to root rot. It is being tested by some growers. Because of the extreme susceptibility to root rot it is being discarded. WSU 908 is a late season selection that was being tested by some growers. It is being discarded because grower response. WSU 994 and WSU 1024 are continuing with grower tests.

WSU 991 was recommended for release in 1994, but was virus infected. Bob Martin has treated plants of WSU 991 and obtained plants that do not appear to have the dsRNA. However, since the organism is unknown, plants will be held over winter and retested after regrowth prior to release.

Table 1. 1994-1995 harvests of 1992 planted raspberries at Vancouver, Puyallup and Mt. Vernon, WA.

	Yield (t/a)			Fruit Rot (%)		Fruit Weight (g)		Harvest Season			
	1995	1994	Two Year Total	1995	1994	1995	1994	5%	50%	95%	Length
Glen Ample	14.6	10.9	25.5	9	2	4.7 A	4.9	6/19	7/2	7/18	29
Meeker	13.2	9.1	22.3	5	3	3.5 C - D	3.7	6/20	7/4	7/19	29
Chilcotin	13.7	8.0	21.7	7	6	4.0 B	4.0	6/17	7/1	7/19	32
WSU 988	11.8	9.7	21.5	11	5	3.8 C - D	4.3	6/18	6/30	7/17	29
Tulameen	10.8	7.7	18.5	8	4	4.7 A	4.4	6/20	7/2	7/18	28
Willamette	10.1	8.3	18.4	8	3	3.5 C - D	3.7	6/16	6/27	7/12	25
WSU 1007	9.7	7.8	17.5	11	3	4.0 C B	4.2	6/21	7/6	7/23	31
WSU 985	9.3	6.0	15.3	9	5	3.1 E	3.3	6/15	6/28	7/11	27
Chilliwack	8.8	6.2	15.0	7	3	3.3 E D	3.6	6/20	7/1	7/14	24
WSU 991	8.5	6.4	15.0	11	6	4.6 A	4.8	6/16	6/27	7/10	25
Average	11.0	8.0	19.1	9	4	3.9	4.1	6/18	7/1	7/16	28

Means are the average of three 3 hill plots at each location.
There were significant effects of clone and location for all variables.
There were significant clone x location interactions for all variables except 1995 fruit weight.
Means within a column followed by the same letter are not significantly different using Duncan's Multiple Range Test, P=0.05.

Table 2. 1994-1995 harvest of 1992 planted raspberries, Mt. Vernon, WA.

	Yield						Fruit Weight (g)		Harvest Season			
	1995		1994		Two Year Total							
Clone	(t/a)	% of Meeker	1995 (t/a)	% of Meeker	(t/a)	% of Meeker	1995	1994	5%	50%	95%	Length
WSU 984	**24.6** a	**151**	**16.5** a - c	**108**	**41.1** a	**130**	**4.4** a - d	**4.6** a - c	**6/22** b c	**7/8** a	**7/20** c - e	**28** b - d
GLEN AMPLE	**19.7** a - c	**121**	**18.5** a	**122**	**38.2** a b	**121**	**4.5** a - c	**4.7** a b	**6/21** c - e	**7/4** b	**7/21** c d	**30** a - c
QUALICUM	**17.5** a - c	**108**	**17.1** a b	**112**	**34.6** a - c	**110**	**4.4** a - d	**4.9** a b	**6/22** b c	**7/4** b	**7/19** d - g	**26** d - f
CHILCOTIN	**21.0** a b	**129**	**13.3** b - d	**87**	**34.3** a - c	**109**	**4.0** b - e	**4.2** b - f	**6/20** c - e	**7/2** b c	**7/22** b c	**32** a
TULAMEEN	**17.8** a - c	**109**	**16.3** a - c	**107**	**34.1** a - c	**108**	**4.5** a - c	**5.1** a	**6/20** c - e	**7/2** b c	**7/19** c - f	**29** a - d
WSU 988	**16.3** a - c	**100**	**16.0** a - c	**105**	**32.3** a - c	**103**	**4.0** b - e	**4.3** b - f	**6/19** d e	**6/29** c	**7/16** g	**27** c - e
ORUS 576-47	**17.7** a - c	**109**	**14.5** a - d	**95**	**32.2** a - c	**102**	**3.9** c - f	**4.4** a - e	**6/28** a	**7/9** a	**7/25** a	**27** c - e
MEEKER	**16.3** a - c	**100**	**15.2** a - d	**100**	**31.5** a - c	**100**	**3.4** e - g	**3.7** d - g	**6/21** c d	**7/4** b	**7/20** c - e	**29** a - d
ORUS 2078	**15.5** b c	**95**	**14.4** a - d	**95**	**29.9** a - c	**95**	**4.4** a - d	**4.5** a - d	**6/22** b c	**7/8** a	**7/23** a b	**31** a b
WSU 994	**16.9** a - c	**104**	**11.5** c d	**76**	**28.5** b c	**90**	**4.6** a b	**4.5** a - c	**6/21** c - e	**7/2** b c	**7/20** c - e	**29** a - d
WSU 1007	**14.0** b c	**86**	**14.0** a - d	**92**	**27.9** b c	**89**	**3.8** d - f	**3.9** c - f	**6/24** b	**7/9** a	**7/25** a	**31** a b
COMOX	**12.5** b c	**77**	**14.7** a - d	**96**	**27.2** b c	**86**	**4.1** a - d	**4.4** a - f	**6/20** c - e	**7/4** b	**7/18** e - g	**27** c - e
WILLAMETTE	**14.1** b c	**86**	**12.9** b - d	**85**	**26.9** b c	**86**	**3.3** f g	**3.7** e - g	**6/19** d e	**6/29** c	**7/12** h	**23** f g
WSU 985	**11.3** c	**69**	**12.0** b - d	**79**	**23.3** c	**74**	**3.1** g	**3.1** g	**6/18** e	**6/29** c	**7/13** h	**24** e - g
WSU 991	**12.2** b c	**75**	**10.5** d	**69**	**22.8** c	**72**	**4.8** a	**4.6** a - c	**6/20** c - e	**7/1** b c	**7/13** h	**23** g
CHILLIWACK	**12.6** b c	**77**	**10.2** d	**67**	**22.7** c	**72**	**3.3** e - g	**3.6** f g	**6/22** b c	**7/3** b c	**7/17** f g	**25** e - g
Average	**16.3**		**14.2**		**30.5**		**4.0**	**4.3**	**6/21**	**7/3**	**7/19**	**28**

Means are averages of three 3 hill plots.

Means within columns followed by the same letter are not significantly different using Duncan's Multiple Range Test, p=0.05.

Table 3. 1994-1995 harvest of 1992 planted raspberries, Vancouver, WA.

	Yield (t/a)			Fruit Weight (g)		Harvest Season			
Clone	1995	1994	Two year Total	1995	1994	5%	50%	95%	Length
WSU 988	**11.2** a - d	**8.7** a	**19.9** a	**4.8** b - d	**4.6** d e	**6/18** c d	**7/2** b - d	**7/19** b c	**31** a - c
Chilcotin	**12.5** a	**6.7** a b	**19.2** a b	**4.5** c - e	**4.4** d - f	**6/16** d e	**7/1** b - e	**7/17** c - e	**32** a - c
Glen Ample	**12.5** a	**6.1** a - c	**18.6** a b	**4.9** a - d	**5.2** b c	**6/16** d e	**7/1** b - e	**7/16** c - f	**30** a - d
Meeker	**12.0** a b	**4.8** b - d	**16.9** a - c	**3.9** e - g	**3.9** f - h	**6/22** b	**7/5** a b	**7/18** c - e	**25** d e
WSU 994	**12.7** a	**4.1** b - e	**16.8** a - c	**4.8** b - d	**5.6** a b	**6/14** e f	**6/30** c - e	**7/14** c - g	**30** a - d
WSU 1009	**8.9** b - f	**6.7** a b	**15.6** a - d	**5.5** a	**5.1** b c	**6/18** c d	**6/28** d - f	**7/11** f g	**23** e
WSU 983	**11.7** a - c	**3.7** b - e	**15.4** a - d	**4.0** e - g	**3.9** f - h	**6/16** d e	**6/29** d - f	**7/17** c - f	**31** a - c
WSU 968	**9.8** a - e	**4.9** b - d	**14.7** b - d	**3.4** g h	**4.0** e - h	**6/15** d e	**7/2** b - d	**7/18** c d	**33** a b
WSU 1021	**8.4** c - f	**6.2** a - c	**14.7** b - d	**3.7** g h	**3.6** g - i	**6/26** a	**7/8** a	**7/30** a	**34** a
Willamette	**8.3** d - f	**6.2** a - c	**14.5** b - e	**3.7** g h	**4.1** e - g	**6/13** e f	**6/27** e f	**7/12** e - g	**29** a - d
WSU 991	**9.1** b - f	**4.3** b - e	**13.3** c - f	**5.1** a b	**5.8** a	**6/12** f	**6/25** f	**7/10** g	**28** b - d
WSU 1007	**9.3** a - f	**3.4** c - e	**12.7** c - f	**4.4** d - f	**4.8** c d	**6/21** b c	**7/5** a b	**7/23** b	**32** a - c
Chilliwack	**8.1** d - f	**3.9** b - e	**12.0** c - f	**3.9** f g	**4.1** e - h	**6/20** b c	**6/30** c - e	**7/16** c - f	**26** d e
WSU 985	**9.6** a - e	**2.1** d e	**11.6** d - f	**3.2** h	**3.5** h i	**6/11** f	**6/29** d - f	**7/13** d - g	**31** a - c
ORUS 1836	**5.9** f g	**3.8** b - e	**9.7** e f	**3.6** g h	**3.4** i	**6/22** b	**7/4** b c	**7/17** c - e	**25** d e
Tulameen	**7.3** e f	**1.4** e	**8.7** f g	**5.0** a - c	**4.1** e - h	**6/22** b c	**7/4** b c	**7/19** b c	**27** c - e
Kiska	**3.3** g	**1.4** e	**4.6** g	**2.2** i	**2.5** j	**6/7** g	**6/19** g	**6/30** h	**23** e
Average	**9.4**	**4.6**	**14.1**	**4.2**	**4.3**	**6/17**	**6/30**	**7/16**	**29**

Means are averages of three 3 hill plots.

Means within columns followed by the same letter are not significantly different using Duncan's Multiple Range Test, p=0.05.

Table 4. 1994-1995 harvest of 1992 planted raspberries, Puyallup, WA.

	Yield (t/a)			Fruit Rot (%)		Fruit Weight (g)		Fruit Firmness (g)		Harvest Season			
	1995	1994	Two Year Total	1995	1994	1995	1994	1995	1994	5%	50%	95%	Length
GLEN AMPLE	11.7 a	8.1 a	19.8 a	25 a - f	4 f	4.7 a	4.7 a	187 a b	242 a - c	6/20 c - h	7/1 f g	7/18 b - g	28 a - d
MEEKER	11.1 a b	7.4 a - c	18.5 a b	12 g - j	6 d - f	3.1 i - k	3.5 g - k	135 f - h	160 g - j	6/18 e - i	7/5 b - e	7/20 b - e	32 a
WSU 1067	9.1 a - d	7.3 a - c	16.4 a - c	18 d - i	7 c - f	3.5 e - j	3.7 e - i	143 e - h	139 h - j	6/25 a	7/3 d - f	7/20 b - f	24 c - e
ORUS 576-47	8.1 b - e	7.9 a b	16.0 a - d	15 f - i	3 f	3.4 e - j	4.4 a b	177 a - d	212 b - f	6/25 a b	7/7 b c	7/22 a - c	27 a - e
ORUS 2078	10.3 a - c	5.5 c - f	15.8 a - e	17 e - i	7 c - f	4.4 a - c	4.2 b - d	155 c - h	156 g - j	6/24 a - c	7/7 b	7/22 a b	28 a - d
WSU 1066	8.1 b - e	7.3 a - c	15.4 a - e	19 c - i	14 a	4.1 a - e	4.3 a - c	148 d - h	188 d - g	6/17 f - i	6/25 k	7/10 j - l	23 d e
WSU 1063*	5.9	9.5	15.3	20	7	3.4	4.0	170	216	6/19	6/30	7/12	23
WSU 1064	7.4 c - f	7.1 a - c	14.5 b - f	18 d - i	9 b - e	3.3 g - k	3.9 c - f	142 e - h	171 f - i	6/25 a	7/5 b - d	7/21 b - d	25 b - e
WSU 984	7.9 b - f	5.8 c - f	13.7 c - g	25 a - e	12 a b	3.9 c - h	4.0 b - e	161 a - h	221 a - e	6/20 b - g	7/3 d - f	7/20 b - d	30 a - c
WILLAMETTE	7.9 b - f	5.8 c - f	13.6 c - g	21 b - h	7 c - f	3.4 f - k	3.4 h - k	145 e - h	173 f - i	6/17 f - i	6/26 i - k	7/11 j - l	24 c - e
WSU 1068	6.3 d - f	7.1 a - c	13.5 c - h	30 a b	13 a	3.9 c - h	4.3 b c	139 e - h	178 e - i	6/15 h i	6/24 k	7/10 j - l	25 b - e
WSU 1071	8.5 a - e	4.8 d - f	13.3 c - h	21 b - g	9 b - e	4.0 b - f	3.9 c - g	148 d - h	120 j	6/18 d - i	6/29 g h	7/15 f - i	27 a - e
COMOX	7.5 c - f	5.8 c - f	13.3 c - h	23 a - f	7 c - f	3.9 c - h	4.0 b - e	166 a - f	224 a - d	6/17 f - i	7/1 f g	7/14 g - j	27 a - e
TULAMEEN	7.2 c - f	5.5 c - f	12.8 c - h	20 c - i	10 a - d	4.7 a b	3.9 c - f	191 a	169 f - i	6/18 f - i	7/1 f g	7/16 d - i	29 a - d
WSU 994**	7.8	4.6	12.4	25	11	4.6	4.9	168	158	6/17	6/30	7/16	29
WSU 988	7.8 b - f	4.5 d - f	12.3 c - h	28 a - c	14 a	4.0 c - h	4.0 b - f	131 h	183 d - h	6/17 f - i	6/29 g h	7/17 d - i	30 a - c
WSU 1007	5.9 d - f	6.0 b - e	11.9 c - h	31 a	6 c - f	3.8 c - i	3.8 d - h	169 a - e	259 a	6/19 d - i	7/3 d - f	7/20 b - d	31 a b
WSU 1065	7.0 c - f	4.8 d - f	11.8 c - h	20 c - i	10 a - c	4.2 a - d	3.3 i - l	146 e - h	141 h - j	6/18 f - i	6/29 g h	7/13 h - k	25 b - e
WSU 1069	5.4 d - f	6.3 a - d	11.7 c - h	23 a - f	5 e f	4.2 a - d	3.9 c - g	165 a - g	232 a - c	6/21 a - f	7/2 e f	7/17 c - h	27 a - e
CHILCOTIN	7.6 c - f	4.0 e f	11.6 c - h	17 e - i	14 a	3.6 d - i	3.6 f - j	159 b - h	141 h - j	6/16 f - i	6/29 g h	7/18 c - g	32 a
WSU 1072	5.9 d - f	5.7 c - f	11.5 d - h	20 c - i	6 c - f	2.4 l	2.7	147 d - h	144 g - j	6/17 f - i	6/27 h - j	7/12 i - l	26 a - e
WSU 968**	6.2	4.9	11.1	24	6	4.2	3.6	166	202	6/17	6/30	7/16	29
WSU 985	7.1 c - f	4.0 e f	11.1 e - h	22 a - f	12 a b	2.8 j - l	3.2 j - l	145 e - h	153 g - j	6/14 i	6/25 j k	7/9 k l	25 b - e
WSU 1061**	5.7	4.9	10.6	20	4	2.8	2.7	147	179	6/18	7/1	7/18	30
CHILLIWACK	5.7 d - f	4.6 d - f	10.3 f - h	17 e - i	6 e f	2.7 k l	3.1 k -	152 c - h	219 a - e	6/18 d - i	6/29 g h	7/11 j - l	23 d e
WSU 1009	5.9 d - f	4.2 e f	10.1 f - h	18 d - i	9 b - e	3.8 c - i	4.1 b - e	153 c - h	180 e - i	6/18 f - i	6/28 g - i	7/9 k l	21 e
WSU 1021	5.1 e f	4.8 d - f	9.9 f - h	11 h i	5 e f	3.1 i - k	3.9 c - g	180 a - c	252 a b	6/25 a b	7/10 a	7/26 a	31 a b
WSU 1073	5.3 e f	4.6 d - f	9.9 f - h	19 c - i	10 a - d	2.9 j - l	3.3 i - l	134 g h	137 l j	6/23 a - e	7/3 d - f	7/16 e - i	23 d e
ORUS 1836	5.5 d - f	4.0 f	9.4 g h	11 i	4 f	3.3 h - k	2.9 l	161 a - h	160 g - j	6/23 a - d	7/4 c - e	7/20 b - f	27 a - e
WSU 983**	4.5	4.6	9.1	27	7	3.4	3.4	149	199	6/18	6/26	7/12	24
WSU 991	4.3 f	4.5 d - f	8.8 h	28 a - d	14 a	4.0 b - g	4.0 b - f	162 a - h	205 c - f	6/15 g - i	6/25 j k	7/8 l	23 d e
WSU 1070**	4.2	4.5	8.7	29	13	3.8	3.8	137	118	6/17	6/25	7/7	20
WSU 1062**	3.4	4.3	7.6	32	4	2.9	4.2	141	201	6/19	6/30	7/17	28
Average	6.9	5.6	12.5	21	8	3.6	3.8	155	183	6/19	6/30	7/15	26

Means are averages of three 3 hill plots. Means within columns followed by the same letter are not significantly different using Duncan's Multiple Range Test, p=0.05. Only two plots were harvested for clones indicated by **, and one plot for the clone indicated by *. These clones were not included in the statistical analysis, and comparisons must be made cautiously.

Project No.: 13C-3543-4958

Title: Control of Root Weevils in Red Raspberries.

Year Initiated: 1992 Current Year: 1995 Terminating Year: 1995

Personnel:

Carl H. Shanks, Jr., Entomologist, WSU-Vancouver
Lynell K. Tanigoshi, Associate Entomologist, WSU-Vancouver
Steven R. Booth, Research Associate, WSU-Vancouver
Arthur L. Antonelli, Extension Entomologist, WSU-Puyallup

Accomplishments:

1. Some insecticides were identified as being efficacious against adult root weevils.
2. Efficacy data will be submitted to the manufactures and IR-4 program in 1996 with residue work possibly initiated in 1997.
3. Efficacy and practicality of using marigolds for controlling root weevils with be evaluated in late 1995 and early 1996.
4. Barriers to prevent migration of adult black vine weevils proved unsatisfactory under season-long field conditions.

Results:

Field. AC 303,630 (Alert 2SC) at 0.08, 0.16, and 0.32 lb ai/acre and fipronyl (Regent 80WG) at 0.01 and 0.02 lb ai/acre were applied to strawberries with a hand-held boom in 100 gal of water at 150 psi on the afternoon of 21 June 1995. Adult black vine weevils, *Otiorhynchus sulcatus*, were counted after dark on 22 June. All treated plots had only 0-7% as many weevils as the untreated check (Table 1).

AC 303,630 at 0.16 and 0.32 lb ai/acre and fipronyl at 0.02 and 0.04 lb ai/acre, and bifenthrin (Brigade 10WP) at 0.01 lb ai/acre were applied to a field of red raspberries in the afternoon of 28 June 1995. Sprays were applied with a hand-held boom that had six nozzles in 100 gal of water at 120 psi. Adult obscure weevils, *Sciopithes obscurus*, were counted after dark on the night of 30 June. A 60 inch-wide strip of cloth was laid on the ground on each side of each 20 ft long plot and the support wires were shaken vigorously six times. The weevils were counted with the aid of a flashlight. The treated plots all had between 0-7% as many weevils as the untreated plots (Table 2).

AC 303,630, fipronyl and bifenthrin were evaluated for control of a heavy population of strawberry root weevil, *Otiorhynchus ovatus*, and some black vine weevil, in a 2 year-old 'Totem' strawberry field in Burlington. Treatments were replicated 4 times on plots 3 rows wide and 25 ft long in a randomized complete block design. Five 1 ft^2 samples were randomly taken on 20 July from the middle row of each plot beginning at 10 PM with the aid of a flashlight. Treatments were applied on 18 July with a field sprayer at 100 psi delivering 100 gal/acre of finished spray from a hand-held boom with 3 hollow cone D4-45 TeeJet nozzles at 2 mph. Air temperature was ca. 80° F and NW wind speed 3-5 mph. Bifenthrin, all rates of fipronyl and the 0.32 lb ai/acre of AC 303,630 gave good initial knockdown of postharvest adult weevils. A 11 day posttreatment count revealed significant suppression of the treated late season weevil population (Table 3).

Treatments were replicated 4 times on 9 ft x 600 ft plots in a randomized complete block design to a mature field of 'Chilliwack' red raspberries in Vancouver, WA. Treatments were applied on 27 July over rows with a hooded boom sprayer equipped with 13 hollow cone D4-45 TeeJet nozzles at 250 psi that delivered 180 gal/acre at 3 mph. AC 303,630 at 0.16 and 0.32 lb ai/acre, fipronyl at 0.02 and 0.04 lb ai/acre and bifenthrin at 0.1 lb ai/acre were evaluated for field efficacy to control a mixed population of black vine weevil (98%), strawberry root weevil (1%) and obscure root weevil (1%). All treatments were significantly better than the untreated check. Bifenthrin gave excellent knockdown of adult weevils followed by the two rates of fipronyl. Though not significant at the 5% level, average counts for the 0.16 and 0.32 lb ai/acre rates for the black vine weevil were over 10- and 8.5-fold those of observed for bifenthrin (Table 4).

Dormant 'Totem' strawberry plants were planted in a weevil-infested field on 25 April 1995. Plots are single rows 50 ft long and 3.5 ft wide with plants 15 inches apart in the row. Three treatments replicated 4 times in a randomized complete block design consist of 'Tanja' marigold seedlings planted halfway between plants, 4 inches on both sides of each plant and plots without marigold plants are checks. Treatments will be evaluated sometime in March, 1996 by digging 5 strawberry plants from each plot and counting weevil larvae.

Arenas were prepared by digging a 20 cm high and 20 cm deep trench around a 4 m^2 area. The outer side of the trench was vertical and the inner wall cut at a 45° slope. The vertical side of 3 of 4 nonreplicated plots were covered with 4 mil black plastic with the edges buried in the soil. Respective plots with plastic covered vertical walls were configured as: 1) covered with a generous layer of Stikem; 2) covered with Fluron; 3) uncoated plastic and 4) bare soil. A 30 cm^2 piece of plywood was placed in the center of the arena and supported 2 cm above the surface of the soil. Fifty color coded adult black vine weevil per arena were placed under the plywood on 30 May 1995 and observations made after 24 hours and 7 days. After 7 days no weevils were observed in the Fluron, uncoated plastic and bare soil barriers. In the Stikem trench, 37 were trapped in the Stikem and none inside the arena. On 22 August, 50 more weevils were placed in the Stikem lined arena. By this time the surface of the Stikem was very dirty and after 24 hours no weevils were observed in either the arena or trench.

Greenhouse. Three dormant 'Totem' strawberry plants were planted equidistant from each other in 10 inch diameter pots on 21 March 1995. Marigold seedlings of several varieties plus 'Tanja' were grown from seed. On 24 April, the strawberry plants were alternated with marigold plants (5 varieties, 11 treatments) and on 31 July, 150 black vine weevil eggs were scattered on the surface of the soil in each pot. Each marigold variety was replicated 4 times and pots were kept in a randomized complete block design in the greenhouse. Four pots of strawberries received eggs but had no marigold plants and are the checks. The experiment will be evaluated in November, 1995 by counting larvae on the roots of each plant.

Publications: Several of the pesticide efficacy trials will be submitted to the Entomological Society of America's Insecticide & Acaricide Tests for publication.

Table 1. Chemical control of adult black vine weevil on strawberry, Aurora, OR, 1995.

Insecticide	*Rate (lb ai/ac)*	*Mean weevils/plot**
AC 303,630 2SC	0.08	0.3a
AC 303,630 2SC	0.16	0.2a
AC 303,630 2SC	0.32	0.0a
Fipronyl 80WG	0.01	0.0a
Fipronyl 80WG	0.02	0.0a
Check	n/a	4.5b

*Means separation by Tukey's HSD test (P = 0.05).

Table 2. Chemical control of adult obscure root weevil on red raspberry, Aurora, OR, 1995

Insecticide	*Rate (lb ai/acre)*	*Mean weevils/plot**
AC 303,630 2SC	0.16	0.5a
AC 303,630 2SC	0.32	0.0a
Fipronyl 80WG	0.02	0.3a
Fipronyl 80WG	0.04	0.3a
Brigade 10WP	0.10	0.0a
Check	n/a	7.0b

* Means separation by Tukey's HSD test (P= 0.05).

Table 3. Chemical control of strawberry root weevil and black vine weevil on strawberry, Burlington, WA, 1995

Insecticide	*Rate (lb ai/acre)*	*Mean weevils/plot**
AC 303,630 2SC	0.08	10.5ab
AC 303,630 2SC	0.16	6.0bc
AC 303,630 2SC	0.32	2.3cd
Fipronyl 80WG	0.01	1.0cd
Fipronyl 80WG	0.02	0.0d
Fipronyl 80WG	0.005	0.0d
Fipronyl 80WG	0.0025	1.5cd
Brigade 10WP	0.1	3.0cd
Check	n/a	14.5a

*LSD pairwise comparisons of means, P=0.5.

Table 4. Chemical control of black vine weevil, strawberry root weevil and obscure root weevil on red raspberry, Vancouver, WA, 1995

Insecticide	*Rate (lb ai/acre)*	*Mean weevils/plot**
AC 303,630 2SC	0.16	107.5b
AC 303,630 2SC	0.32	85.0bc
Fipronyl 80WG	0.04	38.3cd
Fipronyl 80WG	0.02	57.3bcd
Brigade 10WP	0.1	10.3d
Check	n/a	211.0a

*LSD pairwise comparisons of means, P=0.05.

Project No.: 13C-3543-7960

Title: Management of spider mites on red raspberries by insecticides and plant resistance.

Personnel:

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Carl H. Shanks, Jr., Entomologist, WSU-Vancouver
Patrick P. Moore, Associate Horticulturist, WSU-Puyallup.
Arthur L. Antonelli, Extension Entomologist, WSU-Puyallup.

Year Initiated: 1994 **Current Year:** 1995 **Terminating Year:** 1995

Accomplishments:

1. Laboratory bioassays of registered and experimental insecticides and acaricides indicate that field increases of yellow spider populations may be associated with the development of resistant strains of this mite.
2. Field and greenhouse resistance screening continued with promising results. Resistant clones have been identified for further work, replicated field studies have been established and large-scale screening of seedlings have been established from new crosses from promising parents.

Results:

Chemical Control. Limited bioassays to date were conducted with Brigade (befenthrin), Stalker (AC 303,630), Diazinon, Guthion, (azinphos-methyl) and Kelthane (dicofol). The highest recommended field rate was serially diluted four times. Controls were treated with deionized-distilled water. All tests were conducted on lima bean leaf disks 2 cm in diameter that were placed top side down on cotton pads in 100 x 10 mm glass Petri plates. Females of twospotted spider mite, *Tetranychus urticae*, and yellow spider mite, *Eotetranychus carpini borealis*, were randomly picked from their respective cultures with a 000 camel's hair brush and left to settle for 2 hours on their respective 2 cm leaf disks. Even-aged female *Neoseiulus fallacis* predators, 15 days-old (egg to adult), and both prey species were placed in lots of 5 per leaf disk. Pesticides were applied with a Potter precision spray tower at a pressure of 1 bar, providing 2.2 microliters/cm^2. Each treatment was replicated four times. Concentration/response regression lines were estimated with POLO-PC (LeORA software).

Because of an increasing yearly incidence and late season population levels of yellow spider mite on red raspberries, the first replicated bioassay indicated 48 hour survivorship at 1X field rates to be: Brigade (0%), Stalker (83%), Diazinon (79%), Guthion (90%) and Kelthane (62%). Though very preliminary, these data indicate a selection toward multiple resistance. Of utmost concern was the failure of the experimental insecticide-miticide, Stalker (AC303,630), an uncoupler of oxidative phosphorylation after 48 hours posttreatment. The mode of action of this material may be slower acting than expected, as our 144 hour posttreatment counts indicated 36% survival of adult females. The pyrethroid Brigade provided excellent initial knock-down of all 3 mite species, but will commonly enhance late season population increase of twospotted spider mite. Field implication of these finds will be evaluated during 1996 season.

Plant resistance. Seven raspberry clones in the *Rubus* collection at Farm 5 at WSU-Puyallup appeared to be resistant to spider mites in 1994. Some of them are replicated inadequately and none were replicated more than three times. Therefore, root cuttings were taken from them in March 1995 and four or five plants were propagated for each clone. 'Willamette' (susceptible) plus 'Dormanred' and *Rubus parvifolius* 'Cherry' (both resistant) were also propagated for checks. The plants were grown in a greenhouse. Four biweekly mite counts were made from June 27 to August 8. A total of 470 mites per leaflet were counted on 'Willamette' while 'Dormanred' and 'Cherry' had only 6% that many mites. WSU 968 had only 4% and WSU 822 had only 10% as many mites as did 'Willamette'; WSU 1049 and St. Regis (Ranere) had 37-39% as many; while 'Goldenwest', 'September', WSU 805, and BC 74-11-41 had 47-68% as many. All resistant *Rubus* clones should be tested against the twospotted spider mite, *Tetranychus urticae*, and the yellow spider mite, *Eotetranychus carpini*, as the two species may affect clones in different ways.

Table 1. *Rubus* resistance to spider mites in the greenhouse.

Cultivar	No. mites/leaflet	% of no. of mites on Willamette
WSU 968	20	4
Rubus parvifolius	28	6
'Cherry'	29	6
Dormanred	29	6
WSU 822	45	10
WSU 1049	174	37
St. Regis (Ranere)	183	39
September	222	47
BC 74-11-41	295	63
WSU 805	300	64
Goldenwest	470	100

In 1994, 159 red raspberry seedlings that had WSU 968 (spider mite-resistant) and WSU 530, WSU 991, Brandywine, or Schonemann as parents were tested for resistance to spider mites. Those which had <25% as many mites as 'Willamette' (mite-susceptible) were planted in the field at WSU-Vancouver in March 1995. There are 66 seedlings plus the above four parent clones plus 'Willamette' (susceptible check). All are replicated four times.

WSU 968 was crossed with 'Cherokee', 'Sunrise', 'Meeker', 'Chilliwack', 'Glen Ample', 'Nootka', 'Tulameen', WSU 1024, WSU 1027, and WSU 994 in 1994. A total of 921 seedlings from those crosses plus 'Willamette' were planted in the field at WSU-Vancouver in 1995.

A series of new crosses from resistant parents were made in Puyallup in 1995 which should generate 900-1000 seedlings for screening in 1997.

PROJECT NO.: **13C-3555-2783, PART A**

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

PERSONNEL: **J. Scott Cameron**, Associate Horticulturist and Associate Professor
Chuhe Chen, **Stephen F. Klauer,** Research Associates
A. Smith, **B. Kelley**, **A. Vega** and **T. Kostman**, Graduate students
WSU Research and Extension Unit, Vancouver
Kassim Al-Khatib, Assistant Weed Scientist
Carl Libbey, Research Technologist II
WSU Research and Extension Unit, Mt. Vernon

REPORTING PERIOD: 1993-1995, Termination Report

ACCOMPLISHMENTS: ***1993***

☑ Established new caneburning field trials at Vancouver and Mt. Vernon
☑ Supporting data for Section 18 for use of GOAL for caneburning in 1993
☑ Initiated study in nonchemical primocane control at Vancouver

1993 RESULTS: New field trials were established at Vancouver and Mt. Vernon with GOAL (oxyfluorfen), IGNITE (glufosinate), UniRoyal C4243 and MON 13200 (Monsanto). In most cases, primocane control was adequate, however, as expected, preliminary analysis of first year yield component data indicates few significant relationships. Oxyfluorfen performed well at lower rates, and higher rates tended to increase yields & berry size. IGNITE tended to be slower acting but has potential. UniRoyal C4243 also looks promising. MON 13200 does not merit further testing.

A nonchemical method (180 mph blown air) provided primocane height control at harvest equal to oxyfluorfen, but reduced yields due to lower fruit numbers, probably through flower removal by wind.

ACCOMPLISHMENTS: ***1994***

☑ Collected data for caneburning field trials at Vancouver and Mt. Vernon evaluating Goal (oxyfluorfen) and Ignite (glufosinate) for primocane suppression
☑ Supporting data for Section 18 for use of GOAL for caneburning in 1994
☑ Continued research in nonchemical methods at Vancouver where wind as a thigmic stress was found to control height at harvest as well as to increase yield.

1994 RESULTS: Field trials established at Vancouver and Mt. Vernon continued with GOAL (oxyfluorfen) and IGNITE (glufosinate). UniRoyal C4243 and MON 13200

(Monsanto) were dropped, the former due to lack of company interest, the latter due to ineffectiveness. Oxyfluorfen performed well at lower rates, and higher rates tended to increase yields and berry size. IGNITE tended to be slower acting but could perform as well as GOAL. A nonchemical primocane suppression method (180 mph blown air) provided primocane height control at harvest equal to oxyfluorfen, and increased yield significantly over an untreated control.

ACCOMPLISHMENTS: ***1995***

- ☑ Collected data for caneburning field trials evaluating Goal (oxyfluorfen) and Ignite (glufosinate) for primocane suppression at several rates
- ☑ Supporting data for Section 18 for use of GOAL for caneburning in 1995
- ☑ Gramoxone Extra (paraquat) tested as a caneburning alternative
- ☑ Spray additives tested to enhance the efficacy of Ignite
- ☑ Completed studies in thigmic stress (wind) as a primocane suppression method

1995 RESULTS: Field trials with GOAL (oxyfluorfen) and IGNITE (glufosinate). Oxyfluorfen and glufosinate provide adequate primocane control, but no increases in yield were seen in treated plots. Gramoxone gave incomplete primocane suppression compared to Goal. The efficacy of Ignite was greatly enhanced by the addition of 2% ammonium sulfate or 0.5% Sylgard 309 (silicon type surfactant), and primocane regrowth was faster than with Goal. A nonchemical primocane suppression method (180 mph blown air) provided primocane height control at harvest equal to oxyfluorfen, and increased yield significantly over untreated controls.

SUMMARY

Throughout this project, new materials have been tested while promising materials have been placed into the registration process (Goal) and into IR-4 testing (Ignite). In the interim, each year a Section 18 for Goal has been supported by this research. While Goal is not an ideal material, it is certainly effective when used judiciously. The residual activity of Goal can create deleterious delays in primocane regrowth. Ignite can be less effective than Goal in efficacy of suppression, but it does not have a residual component and thus is "softer" on primocane regrowth. However, lower efficacy of Ignite can lengthen the period required for complete burning, thus still causing delay in primocane regrowth. Increased efficacy of Ignite through additives and surfactants can overcome this problem by greatly increasing the efficacy of Ignite. Thigmic stress in the form of 180 mph wind suppressed the growth of primocanes, while cane height control was similar to oxyfluorfen and yields were increased. High wind speed did not reduce photosynthesis, but mechanical stress and movement does cause callose deposition within phloem.

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PROJECT NO.: NEW\RENEWAL OF 13C-3555-2783 PART A

YEAR INITIATED: 1993 CURRENT YEAR: 1995 TERMINATING YEAR: 1998

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

PERSONNEL: **J. Scott Cameron**, Associate Horticulturist and Associate Professor
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Kassim Al-Khatib, Assistant Weed Scientist
Carl Libbey, Research Technologist II
WSU Research and Extension Unit, Mt. Vernon

JUSTIFICATION: The loss of dinoseb for caneburning in red raspberries left the red raspberry industry without an effective tool for primocane suppression. In recent years, researchers in Washington, Oregon, and British Columbia have sought to register alternatives, and, after screening many compounds in Washington, oxyfluorfen (GOAL) has been used on a Section 18 basis for five years with some success. Enquik has also been used with mixed results.

Two major problems currently exist with regard to primocane management in Washington. The first is our continued general reliance on chemicals for primocane suppression. The second is our continued reliance on a limited number of compounds for this critical management practice. In general, the use of herbicides for primocane suppression in red raspberries presents a number of dilemmas. These chemicals are applied directly to the crop plant while it is actively growing with the purpose of killing part of the plant. Herbicides can also be harmful for the long term productivity of the plant. In addition, chemical companies often are not interested in minor use registrations for high value, low acreage crops.

The purpose of this project is to identify compounds suitable for caneburning which have potential for registration. Fewer and fewer compounds have become available for testing. Another major objective of the project is to increase the efficacy of the materials we currently have available. Our goal is to provide industry with more flexible strategies for caneburning both now and in the future. Testing and registration efforts are being coordinated with Oregon and British Columbia, however, differences in cultural and regulatory environments requires Washington to test and register compounds for our own industry's needs.

OBJECTIVES: **(All objectives to be addressed in 1996)**

1. Evaluate field trials of new caneburning compounds for Washington.
2. Collect residue and efficacy data in order to work toward the registration of promising new caneburning compounds.
3. Study possible nonchemical methods of primocane management.
4. Study methods and spray additives by which the efficacy of potential caneburning compounds can be increased.

PROCEDURES:

FIELD TRIALS established in 1993 at Vancouver will continue in 1996. Plots are 10' in length containing three hills trained in a modified hedgerow. Materials being tested include GOAL (oxyfluorfen) at three rates and IGNITE (glufosinate) at two rates. All treatments are compared to an untreated control. Yield estimations are accomplished by removing and analyzing four random canes per plot just before harvest. During each week of harvest, plots are partially harvested in a random manner and the weight of 50 berries recorded. Yield potential will be estimated on both a per acre and per cane basis. At the end of the season, primocane numbers per plot will be recorded. Promising compounds will be pursued for possible registration as efficacy data is collected and residue trials will be initiated as appropriate. **Any new compounds or known alternatives which become available for testing on red raspberry in 1996 will first be applied as an observational trial at Mt. Vernon. Replicated field trials will only proceed if practical to do so given material availability, potential or progress in registration on other crops, company support and compound uniqueness or desirability.**

NONCHEMICAL METHODS of primocane suppression will continue to be investigated, and new ideas will be tested in observational trials in 1996. Hot water and steam delivery systems will be considered and tested as available. Antitranspirants will again be applied as a potential primocane suppression strategy in 1996. Several materials and rates will be tested in the field and greenhouse.

ENHANCED EFFICACY TRIALS initiated at Mt. Vernon in 1995 will continue with two rates of Ignite (0.5 and 0.75 lb ai\A) applied without adjuvants, with 1% Sylgard 309, 1% nonionic surfactant, 1% crop oil, or 2% ammonium sulfate. Results will be compared with oxyfluorfen. Enhancing the efficacy of Ignite in red raspberry is an important part of developing its potential use as a primocane suppression tool.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

Benefits: We anticipate that additional caneburning materials will become available to industry as new compounds enter the registration process. We know considerably more about primocane biology and red raspberry productivity now than we did when we first started to screen dinoseb alternatives in the late 1980's. This allows us to identify advantages and disadvantages of these compounds from an enhanced perspective and with a view to the future. Additionally, we are investigating alternative, nonchemical strategies of primocane management. This appears to be the reality for the future of sustainable raspberry culture and thus demands a proactive position in seeking new methods of primocane control.

Information \ Technology Transfer: 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. As promising techniques and cultural practices are determined, it is our intention to work with WSU Cooperative Extension personnel to develop demonstration plots.

BUDGET:

		1995 REQUEST	
		MT. VERNON	VANCOUVER
01	Wages	$3,000	$3,700
03	Supplies and Services	750	500
04	Travel	500	-----
07	Benefits (16%)	480	592
LOCATION SUBTOTAL		$4,730	$4,792

TOTAL REQUEST $9,522 - *FUNDING RECEIVED $8,000*

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

TOTAL $12,922

OTHER SUPPORT OF PROJECT:

No other support is available for this research. The red raspberry industry is the sole end user of this service work. These projects thus require industry support.

PROJECT NO.: **13C-3555-2783, PART B**

TITLE: **CANEBURNING MANAGEMENT AND PRIMOCANE BIOLOGY**

PERSONNEL: **J. Scott Cameron**, Associate Horticulturist
Chuhe Chen, Stephen F. Klauer, Postdoctoral Research Assoc
A. Smith, B. Kelley, A. Vega & T. Kostman, Graduate students
WSU Research and Extension Unit, Vancouver

REPORTING PERIOD: 1993-95, Termination Report

ACCOMPLISHMENTS: ***1993***

- ☑ Monitored\analyzed yield component relationships in primocane control study
- ☑ Monitored primocane regrowth during the season in primocane control study
- ☑ Initiated study of thigmomorphogenesis for nonchemical primocane control
- ☑ Radioactive labeling studies for determination of intraplant competition

RESULTS: Yield components of low to medium vigor plants were not strongly impacted by chemical caneburning regimes in the first year. Primocane regrowth was influenced by compound and rate. Blown air (180 mph) provided primocane height control (up to 20-30%) by harvest equal to oxyfluorfen, but reduced yields due to lower fruit numbers. A graduate student (TK) is investigating mechanisms of thigmomorphogenesis applicable for primocane control.

Radioactive labeling at different stages of plant development provided considerable new information about plant carbon dynamics. At four stages: flowering, green fruit, red fruit and postharvest, products of photosynthesis moved from floricanes to primocanes, but, movement into floricanes from primocanes was not readily detected. The root system was labeled at all stages, thus identifying roots as a major competing sink. Primocanes were still a sink at 4' in length and fed each other. Long after harvest when assumed useless, senescing floricanes were still fixing and exporting carbon, raising new questions about their biology and importance.

ACCOMPLISHMENTS: ***1994***

- ☑ Observed altered yield components due to primocane management as fruit number per cane determines yield, and compensatory relationships among lateral number (internode length) and length determines fruiting density
- ☑ Significant differences in primocane growth in response to primocane control method
- ☑ Studies undertaken in the field and greenhouse to test thigmic stress (180 mph wind) as a primocane suppression agent.
- ☑ Radioactive labeling demonstrated that primocanes are a competitive sink at all times, and that three major sinks: roots, primocanes and fruit, peak in demand at the same time.

RESULTS: Yield components were altered by chemical primocane management as a compensatory relationship was observed among berry number, lateral length and lateral number. Yield component characteristics in response to Goal and Ignite were rather similar, and a lower rate of Ignite may be sufficient for many plantings. Primocane regrowth was influenced by compound and rate. In the field, thigmic stress (180 mph wind) provided highest yields compared to control and chemical treatments. In the greenhouse and field, thigmic stress did not reduce photosynthesis but may reduce carbohydrate storage. Increased levels of callose deposition appear to have occurred in the phloem of thigmically stressed plants. Radioactive labeling at different stages of development provided new information about carbon dynamics. Primocanes have always been considered to be a competing sink. One floricane or primocane was bagged for 24 hours and label was followed for up to 11 days. At all stages (early anthesis, green fruit, red fruit, postharvest), label moved from a labeled floricane to primocanes (from 2.5 cm to 1.5 m tall) and roots. Movement was quickest and greatest at anthesis, decreased during fruiting, and was still occurring two months after harvest. Label was detected in roots of labeled primocanes at all stages, but trace amounts were present in fruit and other primocanes late in development. Unfortunately, three major sinks of the raspberry plant, fruit, primocanes and roots, all peak in their demand at about the same time.

ACCOMPLISHMENTS: ***1995***

- ☑ Yield components examined (multi-year) in response to Goal and Ignite.
- ☑ Primocane growth curves generated for long term Goal and Ignite treatments.
- ☑ Field and greenhouse studies testing thigmic stress (180 mph wind) for primocane suppression while studying physiological influence of wind\mechanical stress.
- ☑ Preliminary study using antitranspirants for nonherbicidal primocane suppression.

RESULTS: Oxyfluorfen and glufosinate continue to provide adequate primocane control in field trials, with herbicide rate positively correlated with yield, but with yields not significantly different than from untreated controls. Increases in yield per cane via berry number accounted for differences among rates with no change in berry size. Primocane development patterns amongst treatments across the season were more similar this year than in previous years. Preliminary trials with anti-transpirants for primocane suppression had mixed success. In large pots, primocanes 12, 30 and 54 inches in height were treated with an antitranspirant. Physiological response was inconsistent, but some differences in cane diameter and height were observed. Thigmic stress (180 mph blown air) provided adequate primocane suppression and did not reduce photosynthesis, and callose deposition in the phloem of stressed plants was much higher after treatment and cumulatively during the season.

PUBLICATIONS:

Cameron, J.S. 1993. Primocane management of red raspberries. Research Updates: CAHE, Washington State University, p. 2.9.

Cameron, J. S. 1993. Raspberry productivity: Assessing the physiological costs of cultural management, pests and environmental stress (Invited participant). Proceedings of the Conference on Setting *Rubus* Research Priorities for Canada. Sponsored by Agriculture Canada, Simcoe, Ontario, Jan 12-13, p. 28.

Cameron, J.S., Chen, C., Klauer, S.F., and P.W. Foote. 1993. Evaluation of the Minolta CM-2002 Portable Spectrophotometer for Nondestructive Estimation of Leaf Chlorophyll Content and Photosynthetic Activity. Technical Report to the Minolta Corproation, 7 pp.

Cameron, J.S. 1993. Horticultural and Physiological Research in Small Fruit Crops at The WSU R&EU, Vancouver - Research Reports (5) for the USDA-CSRS Northwest Center for Small Fruit Research Annual Meeting, Pasco, WA, Nov 17-18.

Cameron, J.S. 1993. Caneburning and red raspberry productivity: The quest for optimal growth management practices. Lower Mainland Horticultural Improvement Association Growers' Short Course. 35: 10-14.

Cameron, J.S. 1993. Growth and Productivity of the Red Raspberry Plant: Physiology and Yield Efficiency. Lower Mainland Horticultural Improvement Association Growers' Short Course. 35: 17-23.

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Cameron, J.S. 1994. New Perspectives on Red Raspberry Primocane Management. Proc. W. Wash. Hort. Assoc. 83: 101-105.

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Cameron, J.S. 1994. Photosynthesis and Productivity: What Really Determines Small Fruit Yields. Proc. 1994 Tri-State Fruit and Vegetable Meetings,

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Cameron, J. S. 1994. Developmental and Environmental Biology of Red Raspberry. Invited review. Acta Hort. 352:113-121.

Klauer, S.F., Cameron, J.S. and P.F. Foote. 1994 $^{14}CO_2$ Movement between floricanes and primocanes in red raspberry during the fruiting cycle. HortScience , 29:539.

Kostman, T., Cameron, J.S., Chen, C., and S.F. Klauer. 1995. Potential of blown air as a thigmic stress for temporary nonchemical primocane suppression of red raspberry. HortScience , 29:458.

PROJECT NO.: **13C-3555-4784, TERMINATION REPORT**

YEAR INITIATED: 1991 **CURRENT YEAR: 1995** **TERMINATING YEAR: 1996**

TITLE: **THE INFLUENCE OF MITE FEEDING AND MITICIDES ON THE GROWTH AND PHYSIOLOGY OF RED RASPBERRY**

PERSONNEL: **J. Scott Cameron**, Associate Horticulturist
Chuhe Chen, Stephen F. Klauer, Research Associates
A. Smith, B. Kelley, T. Kostman, A. Vega, Graduate students
WSU Research and Extension Unit, Vancouver

REPORTING PERIOD: 1994-95, Termination Report
Note: This project is being terminated in 1995 instead of 1996 in order to more fully integrate the activities of our research with Dr. Tanigoshi's. The new proposal merges the activities of 13C-3543-7960 (Tanigoshi) and 13C-3555-4784 (Cameron), projects to have expired in 1996.

REPORTING PERIOD: 1991-95

ACCOMPLISHMENTS:

1991

☑ Twospotted spider mite feeding can depress photosynthesis
☑ Mite feeding can reduce photosynthetic processes in as little as 6 hrs
☑ Miticides can depress photosynthesis and gas exchange

1992

☑ Limited mite feeding can influence whole plant physiology
☑ Portions of the photosynthetic apparatus damaged by mite feeding are identified

1993

☑ Influence of miticides on physiology characterized at leaf & molecular levels

1994

☑ In the field, photosynthesis depressed up to 36% by Avid for 7-14 days.
☑ In the greenhouse, physiological depression by miticides lasts 10-14 days.
☑ Miticides found to have the same depressive effects on physiology at all major stages of development (bloom, fruit development, postharvest).
☑ Photosynthetic capacity was higher in resistant clone (WSU 968) after infestation versus susceptible standard ('Willamette'), some appear tolerant.

1995

☑ Anatomical comparisons of susceptible\resistant\tolerant leaves initiated

☑ Differences in photosynthetic and chlorophyll biology determined between mite-resistant (WSU 968) and mite-susceptible ('Willamette') standard.

RESULTS: Systemic physiological effects of mite feeding and pesticides have been under study in raspberry and hypotheses as to how mite infestation leads to physiological depressions at the molecular and whole plant levels have been developed. Ongoing research with a range of pesticides has shown that plants respond to various compounds with depressions in physiology lasting for hours to those which can last for 7-14 days. Research has been initiated to study mechanisms of resistance and tolerance in red raspberry. Leaves of resistant and susceptible genotypes are fixed and are being stained and mounted for anatomical analyses. A study is currently characterizing physiological parameters of mite resistant and susceptible raspberry genotypes. WSU 968, a resistant standard, and 'Willamette', a susceptible standard, are being compared anatomically, physiologically and biochemically. WSU 968 has higher rates of photosynthesis and higher chlorophyll (chl) content than 'Willamette' with greater levels of photochemical efficiency. It is possible that factors in photosynthetic efficiency such as higher carboxylation capacity and a greater number of PSI reaction centers per chl content could increase tolerance of mites. This information will become increasingly valuable as the basis for tolerance and resistance is elucidated for more efficient and reliable means of germplasm screening.

PUBLICATIONS:

Antonelli, A., C.H. Shanks, and J.S. Cameron. 1991. Weevil and mite control. Proc. W. Wash. Hort.Assoc. 81:136-142.

Cameron, J. S. 1994. Developmental and Environmental Biology of Red Raspberry. Sixth International Symposium on *Rubus* and *Ribes*, ISHS, Acta Hort.

Cameron, J.S. 1993. Growth and Productivity of the Red Raspberry Plant: Physiology and Yield Efficiency. Lower Mainland Hort Improvement Assoc Growers' Short Course. 35: 17-23.

Cameron, J.S. 1993. Growth Dynamics of the Red Raspberry Plant. Proceedings of the 1993 North American Bramble Growers' Association Annual Meeting. In press.

Cameron, J.S. 1993. Physiology of the Raspberry Plant: The Laboratory and Real Life. Proceedings of the 1993 Oregon Horticultural Society Annual Meeting. In press.

Cameron, J. S. 1993. Raspberry productivity: Assessing the physiological costs of cultural management, pests and environmental stress (Invited participant). Proceedings of the Conference on Setting *Rubus* Research Priorities for Canada. Sponsored by Agriculture Canada, Simcoe, Ontario, Jan 12-13, p. 28.

Cameron, J. S. 1995. Impact of mites and miticides on the photosynthetic biology of strawberry and red raspberry leaves. HortScience, in press.

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

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

PERSONNEL: **J. Scott Cameron**, Associate Horticulturist
Chuhe Chen, Stephen F. Klauer, Research Associates
A. Smith, B. Kelley, T. Kostman, A. Vega, Graduate students
WSU Research and Extension Unit, Vancouver

REPORTING PERIOD: 1995

ACCOMPLISHMENTS: ***1995***

☑ Yield components studied in the field in response to cane density.
☑ Yield components studied in the field in response tying versus topping canes.
☑ Yield components studied in the field in response to date of floricane removal.

RESULTS: As cane density increased from four to 20 canes (4, 8, 12, 16, 20) per hill (cph), yield per cane decreased 40%, while yield potential per area increased from 3.5 T\A (4 cph) to 9.5 T\A (20 cph). While fruit number per cane was negatively correlated with cane density, fruit size was unaffected with the exception of a slight increase in size (9%) at four cph. Little or no change was observed in lateral length or numbers. While the performance of tied versus topped canes at 12 cph was similar in 1994, in 1995, tied canes at 12 cph (15.4 T\A) had yield potentials much higher than topped canes (8.5 T\A). Higher fruit numbers increased yield due to a 122% increase in lateral number, while average lateral length decreased 20%. It appears that in a given year, while more fruit may or may not be recovered from extra cane length tied over, factors affecting bud break (blind or delay) and\or internal physiological conditions should be considered for this inconsistency. The impact of major fluctuations in cropping load such as this must be determined for subsequent crops. A preliminary study in time of floricane removal indicated that later cane removal (Feb vs. Sept) may have increased yields by 12% the following season. This is consistent with our hypothesis that floricanes continue to contribute much needed carbohydrates to the root system after harvest. Dates are being expanded this year to include July, September, November and January. Radioactive labeling work was delayed to allow for optimal plant condition and to wait for the use of a 6' walk-in radioisotope hood facility in our new lab suite at the WSU Vancouver branch campus. Available by the end of January, 1996, this facility will allow for greatly facilitated experimentation in radioisotope labeling and expanded capabilities (larger plants, better environmental control) for this work.

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

YEAR INITIATED: 1991 **CURRENT YEAR: 1995** **TERMINATING YEAR: 1996**

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

PERSONNEL: **J. Scott Cameron**, Associate Horticulturist
Chuhe Chen, **Stephen F. Klauer,** Research Associates
WSU Research and Extension Unit, Vancouver

JUSTIFICATION: Horticultural scientists doing research with red raspberries in the Pacific Northwest routinely estimate crop yield potential to be 3-5X greater than the average yields reported by industry. Previous work has shown that our mechanically-harvested canopy may actually account for the loss of 50% of our potential yield through harvester losses and poor light interception/fruit set. The 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. In its simplest form, yield efficiency relates to obtaining the greatest yield per unit of land area. Theoretically, higher yielding varieties would increase yield efficiency, but we are currently harvesting only a fraction of the yield potential of the cultivars we have. Plant breeding is important for maintaining the productivity of industry, but breeders have little information on where they could most easily make the largest gains.

Price fluctuations due to increasing worldwide tonnage, land and water issues and increasing production costs demonstrates that increasing yield per unit area is a major priority. Given the architecture of our harvesters and losses associated with mechanical harvest, it is clear that training and pruning are critical 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 the cultural biology of this plant while developing new, cost effective strategies to increase the efficiency of red raspberry culture.

OBJECTIVES: **(All to be addressed in 1996)**

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 studies with cost effective approaches to recovering yield potential.

PROCEDURES:

Cane density: In 1996, cane densities of 4, 8, 12, 16 and 20 canes per hill (cph) will again be evaluated for yield components and physiological characteristics. Fruit size and number relationships will be expressed mathematically in concert with other affected yield components. Particular attention will be paid to parameters related to lateral number (internode length), length and fruiting density as they determine potential increases in yield. We will identify those areas of cultural management most impacted by higher density plantings.

Tying vs. Topping: Evaluation of yield component differences between established plots of tied and topped 'Meeker' at 12 cph will continue. The general purpose of this study is to analyze potential sources of increased yield, physiological adaptation and compensation between the two systems. Of special interest will be whether a heavy crop in tied plots in 1995 (15.4 T\A) compared to topped plots (8.5 T\A) will influence carbohydrate balance and relative productivity in 1996.

Radioactive Labeling Studies: A second series of 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 determining a strategy for distributing canes within the row and for 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.

Phenology and Temperature: Red raspberry leaves have a low photosynthetic maximum in the low 70'sF and a higher root temperature optimum around 80F. It is likely that growth and productivity are 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 propose to 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.

"New" 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 is currently being used in Chile in rotary-harvested fields and is an excellent system for several reasons including excellent light penetration through two separate canopies, easier primocane management as well as more efficient harvest. With a 70 cm split at the top and a narrow base, the architecture of this canopy is optimized both for production and harvest. We propose to set up a small trial using this system for evaluation of yield components. If possible, this trial will be set up in a grower's field and harvested by machine.

Influence of Cane Management Practices on Yield Component Relationships:

Date of Floricane Removal: Floricanes are being 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.

Chemical and Non Chemical Primocane Suppression: Plots of primocane suppression treatments will again be analyzed for yield component interactions related to sustainable production. The physiological impact of non chemical methods of primocane control such as antitranspirants will be examined for their influence on normal primocane development. Similar analyses will be conducted for other potential alternative cane management practices such as steam.

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.

Information \ Technology Transfer: This information will be disseminated at regional and national grower's meetings as well as through local, regional, and national publications. As promising techniques and cultural practices are determined, it is our intention to work with WSU Cooperative Extension personnel to develop plots for public demonstration.

BUDGET: ***Note: Some research has been incorporated into this proposal from Project 13C-3555-2783 Part B which was terminated this year without seeking renewal.***

	Requested 1995	Requested 1996
Temporary employees	$6,200	$7,000
Supplies and services	800	1,500
Travel	-----	-----
Equipment	-----	1,200
Benefits (16% of 01)	496	1,120
TOTAL	**$7,992**	**$10,820**
	$7,000 FUNDED	

OTHER SUPPORT OF PROJECT:

No other sources of funding are currently available or pending for this project. This aspect of our research is one which is not easily marketed to federal and private granting agencies due to its focus on the cultivated raspberry which is considered to be a "minor" or "alternative" crop. The red raspberry industry is the sole end user of the applied physiology and field studies we are doing. These projects thus require industry support.

Project No.: 13C-3761-5718

Title: Using Ridomil (metalaxyl) to identify advanced red raspberry selections with resistance to Phytophthora root rot.

Personnel: Peter R. Bristow, Associate Plant Pathologist and Patrick P. Moore, Associate Horticulturist, Washington State University, Puyallup Research and Extension Center

Reporting Period: 1995

Accomplishments: A new planting with 17 genotypes was established on soil naturally infested with *Phytophthora fragariae* var. *rubi* during 1995. Plots scheduled to receive the fungicide Ridomil were treated immediately after planting and again in October. The plants made good growth during the first year. An electric fence around the planting suppressed but did not eliminate browsing by deer.

Table 1. Genotypes (selected varieties and advanced selections planted in 1993.

Cherokee (R)*	WSU 968	WSU 1067
Comox (S)	WSU 1024	WSU 1068
Glen Ample (?)	WSU 1033	WSU 1069
Meeker (I)	WSU 1063	ORUS 576-47
Qualicum (?)	WSU 1064	ORUS 2078
Willamette (S)	WSU 1066	

* Known reaction to root rot: R = resistant, I = intermediate, S = susceptible, and ? = unknown.

Project No.: 13C-3761-5718

Title: Using Ridomil (metalaxyl) to identify advanced red raspberry selections with resistance to Phytophthora root rot.

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

Personnel: Peter R. Bristow , Associate Plant Pathologist and Patrick P. Moore, Associate Horticulturist, Washington State University, Puyallup Research and Extension Center

Justification: Root rot caused by the fungus *Phytophthora fragariae* var. *rubi* is a problem in an increasing number of red raspberry fields. At present the only effective means of control is chemical (both Ridomil and Aliette are registered for this purpose). Sources of resistance have been identified but to date genetic resistance has not been transferred into horticulturally acceptable types. Recently a method was developed to measured the level of resistance in red raspberry genotypes including advanced selections in the breeding program. In brief, the performance of untreated plants is compared with that of plants treated with the fungicide Ridomil when plants are grown in soil naturally infested with the pathogen.

Procedures: A new planting containing 17 genotypes was established on naturally infested soil at the WSU-Vancouver Research and Extension Unit during 1995. Eleven advanced selections from breeding programs in the Pacific Northwest and four varieties whose reactions to this root disease are known were included. Also planted were two new varieties; Qualicum from British Columbia and Glen Ample from Scotland. Glen Ample has yielded extremely well in recent trials conducted at three sites in the Pacific Northwest. Half of the plants of each genotype were treated with Ridomil at planting and then each fall and spring thereafter. The remaining half of the plants serve as the untreated checks.

Cane growth and wilt data will be collected from primocanes produced in 1996 and those primocanes will be trellised for first harvest in 1997. Data will be taken through the second fruiting year in 1998. Because this crop is perennial it is important to make observations for more than one year to make sure resistance identified in the early years persists.

The Agriculture Canada Raspberry Breeding Program in British Columbia tests for resistance in the greenhouse but not in the field or in comparison with healthy plants of the same genotype.

Anticipated Benefits and Information Transfer: Incorporating root rot resistance into commercially acceptable material should reduce and possibly even eliminate the need for fungicidal control. Reducing the amount of fungicide applied to the soil will lower the risk of the pathogen developing resistance to the fungicides, especially Ridomil. Resistant varieties will be able to be grown on sites even though the soils are infested.

The results of this research will be transferred to the users in at least three ways: 1) annual progress reports to the commission, 2) presentations to grower groups such as the Western Washington Horticultural Association and 3) official release of resistant cultivars.

Budget:

Amount allocated by Commission for FY 1995-96: $482

Request for FY 1996-97:

Salaries	
Timeslip	$ 300
Operations	500
Travel	100
Projected needs	
Meetings	
Other	
Equipment	
Employee Benefits	18
Total	$ 948

Current and Pending Support, 1996-97

Title of Project	Total $ amount requested for 1996-97	Granting source from which funding has been requested
Strawberry		
Genetic improvement of strawberry	$17,000	Washington Strawberry Commission
Development of new strawberry cultivars for the Pacific Northwest	$13,500 (received for 1995-96)	Oregon Strawberry Commission
Strawberry cultivar identification by PCR	$ 7,000	USDA NW Center for Small Fruit Research
Virus Elimination for testing of WSU strawberry selections	$ 5,000	USDA NW Center for Small Fruit Research
Raspberry		
Red raspberry breeding genetics and clone evaluation	$27,500	Washington Raspberry Commission
Advanced testing of Washington State University raspberry selections-Mt. Vernon	$ 7,521	Washington Raspberry Commission

Title of Project	Total $ amount requested for 1996-97	Granting source from which funding has been requested
Raspberry		
Advanced testing of Washington State University raspberry selections-Vancouver	$ 2,984	Washington Raspberry Commission
Development of new raspberry cultivars for the Pacific Northwest	$ 4,500 (Received for 1995-96)	Oregon Raspberry and Blackberry Commission
Blueberry		
Evaluation of blueberries at Mount Vernon	$11,663	Washington Blueberry Commission
Small Fruit Requests		
Evaluation of small fruits at WSU Mt. Vernon	$ 4,537	Northwest Ag Research Foundation

Project No.: 13C-3761-6718

Title: The use of raised beds for 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: 1995

Accomplishments: Data from tensiometers demonstrated that soil in and immediately below raised beds was drier than soil in conventional flat beds. The raised bed plots at WSU-Vancouver were replanted and that field trial is now back on track.

Results: The experimental site at WSU-Vancouver was replanted in March 1995 and the certified Willamette plants made good growth during their first year. Plants on the raised beds (top of the bed is 12 inches above the original soil line) were more vigorous than those on flat beds regardless of whether they had been treated with Ridomil. No symptoms of Phytophthora root rot were observed during the first year. Plants in the different treatments will be evaluated for root rot beginning in Spring 1996.

Raised beds were also constructed on two commercial red raspberry farms in Spring 1995 . Soil from the alleyway was thrown up around the base of well established plants to form the bed (ridge). Untreated check areas, where soil was not thrown up around plants, were included at both locations. At one site the bed was 6 inches high. Unfortunately this field was taken out after the 1995 harvest because Phytophthora root rot had killed so many plants. At the other site, beds were 12 inches high. Phytophthora root rot was not detected at this site.

Tensiometers were installed at all three sites to monitor soil moisture tension in the bed and at various depths to 18 inches below the original soil line. Soil 3 inches below the surface of the 12 inch high raised bed was drier (greater moisture tension) than soil at the same depth in flat beds (Table 1). Soil immediately beneath the raised beds was drier than comparable depths beneath the flat bed. This may be due to rain and

irrigation running off into the alleyway on either side of the raised bed rather than percolating through the soil as it does in flat beds. Following heavy rain no differences were found between raised and flat beds. Also, no differences in soil moisture tension were noticed between raised and flat beds when the raised beds were only 6 inches high.

Table 1. Soil moisture tension in raised and flat beds in the field trial at WSU-Vancouver.

Date	Depth below the surface, in.	Soil moisture tension, mbars	
		Raised bed*	Flat bed**
Apr 26	3	-356	-254
	6	-212	-268
	9	-115	
	12	-76	-47
	15	-61	
	18	-52	-16
	24	-28	
	30	-19	
May 16	3	-537	-441
	6	-304	-414
	9	-162	
	12	-107	-61
	15	-86	
	18	-73	-27
	24	-45	
	30	-36	
May 25	3	-306	-222
	6	-158	-129
	9	-89	
	12	-66	-27
	15	-60	
	18	-57	-49
	24	-42	
	30	-40	

* The surface of the raised bed was 12 inches above the original soil line. Top soil taken from an area adjacent to the experimental planting was used to build the raised beds.

** surface of the flat bed is the original soil line.

Project No.: 13C-3761-6718

Title: The use of raised beds for control of Phytophthora root rot.

Year initiated: 1994 **Current year:** 1995 **Terminating year:** 1997

Personnel: Peter R. Bristow Associate Plant Pathologist and Gwenyth E. Windom, Agriculturist Research Technologist III, Washington State University, Puyallup Research and Extension Center and Carol A. Miles, Crop Specialist, WSU Cooperative Extension, Chehalis.

Justification: Recent research conducted in New York State found that damage from Phytophthora root rot (*Phytophthora fragariae* var. *rubi*) was markedly reduced when plants of the susceptible red raspberry variety Titan were grown on raised (14 inches high) beds. Several decades ago, research conducted on strawberries in Puyallup showed that the severity of red stele root rot (*P. fragariae* var. *fragariae*) was lowered when plants were grown on ridges where the distance from the top of the ridge and the bottom of the trough between rows was maintained at 15 inches. In both crops natural drainage away from the roots maintains soil moisture conditions that are unfavorable for the pathogens to produce spores which infect the roots. Currently, a number of red raspberry growers in Washington are throwing soil up around the base of plants to stimulate new root growth and eventually shift rooting into the soil within the ridge. One of the reasons for their doing this is to avoid damage from root rot. It is unknown if this practice will achieve the desired result.

Objectives: 1) To compare the performance of a susceptible red raspberry cultivar grown on a raised bed with plants grown on a conventional flat bed system and 2) to see if throwing soil up around (ridging) plants initially established in the flat bed system will reduce damage from this root disease.

Procedures: Certified plants of the susceptible variety Willamette will be replanted into naturally infested soil at the WSU-Vancouver Research and Extension Unit. Plants will be planted into the center of 14 inch high raised beds and into conventional flat beds. Within each of these two treatments half of the plants will receive twice yearly applications of the fungicide Ridomil to chemically control root rot and the other half will remain untreated. Other plants will be started in the flat bed system (and treated with Ridomil to allow their establishment). Once established soil will be thrown up around the plants and Ridomil applications will be discontinue on one half of the plants.

Anticipated Benefits and Information Transfer The results will tell if planting on raised beds is of has any value for root rot control under Pacific Northwest conditions. It will also demonstrate if forming ridges by throwing soil up around the base of established plants will control this root disease. If either of these cultural practices is shown to be beneficial, it will become part of an integrated approach to control this root disease.

The results will a transferred to the ultimate user in a number of ways including: Field Days, Berry Basket Newsletter, presentations to grower groups such as the annual meeting of the Western Washington Horticultural Association, and written recommendations in the PNW Plant Disease Handbook and the WSU Pest Management Guide for Commercial Small Fruits.

Budget:

Amount allocated by Commission for FY 1995-96: $548

Request for FY 1996-97

Salaries	
Timeslip	$ 600
Operations	1000
Travel	80
Projected Needs	
Meetings	100
Other	
Equipment	
Employee Benefits	95
Total	$1875

Project No.: 13C-3761-7718

Title: Physiological races of the yellow rust fungus in the Pacific Northwest

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

Reporting period: 1995 (final report)

Accomplishments: This year we confirmed the presence of three races of the yellow rust pathogen which were first identified in 1994. Meeker, the most widely grown variety of red raspberry grown in the Pacific Northwest was susceptible to all three races. Teliospores readily overwinter on canes but the importance of this form of overwintering inoculum is questioned.

Results: Reaction of leaf disk from 12 different genotypes inoculated with rust spores (urediniospores) collected from fields in Washington and Oregon confirmed the presence of three races of the pathogen. None of the races attacked leaf disks of Latham, Puyallup, Tahoma and Chilcotin, while all three races infected those of Meeker, Fairview and Washington.

Of 17 genotypes (advanced selection and standard varieties) in a field planting at WSU-Vancouver, all but Chilcotin were susceptible and they varied in the degree of susceptibility (Table 1). Disease severity ratings for the genotypes in 1995 agreed closely with the ratings for 1994 (correlation coefficient = 0.91). Tulameen and WSU-1021 were only slightly susceptible both years.

Disease severity for a given genotype in that planting was not related to the density of teliospores on the surface of overwintering canes (Table 1). For example, Chilcotin which appears to be immune to the disease, had the second highest density. The wind disseminated teliospores adhere to canes by means of a sticky appendage. Even so, many of the spores were apparently washed from the canes by rain during the winter. The density of teliospores on canes in a commercial Meeker field declined by 60% between January and March (Table 2).

Indirect evidence suggests that teliospores on canes may contribute little to the production of primary inoculum in the spring. Teliospores germinate to produce basidiospores which infect newly emerging leaves to begin the disease cycle for the new crop year. In a commercial Meeker field, nearly all of the new infections were on the basal leaves of laterals near the top trellis wire. Old leaves trapped between canes when they were tied to the top trellis wire probably harbored teliospores which led to these new infections. If teliospores on the cane surface were important, one would have expected to see new infection on laterals along the entire length of the cane. Also, no germinated teliospores were observed on the surface of Meeker canes collected in late-March. In contrast, few if any symptoms were observed on leaves along the trellis wire in the WSU-Vancouver planting where old leaves were allowed to drop before canes were tied to the trellis. When symptoms did appear in that planting, they were on leaves near the base of the plant.

Publications:

Bristow, P. R. 1995. Yellow rust: an emerging problem in red raspberries. Proc. West. Wash. Hort. Assoc. 85:157-161.

Bristow, P. R. and M. Derie. 1995. Reaction of red raspberry genotypes to isolates of the yellow rust fungus by leaf disk assay. APS Biol. and Cult. Tests 10:57.

Table 1. Disease severity rating (DSR) and density of teliospores on overwintering canes of genotypes planted at WSU-Vancouver.

Genotype	DSR* mean for 2 years	Teliospore density** no./cm^2
Chilcotin	0.0 a	40.8 b
WSU 1021	0.7 b	4.1 d
Tulameen	0.8 bc	2.1 d
WSU 983	1.1 b-d	5.8 cd
Chilliwack	1.3 cd	7.2 cd
WSU 1009	1.3 c-e	1.8 d
Glen Ample	1.6 d-f	1.4 d
ORUS 1836	1.8 ef	1.6 d
Meeker	1.8 ef	22.0 b-d
Kiska	1.9 fg	38.8 bc
WSU 968	2.6 gh	14.8 b-d
WSU 988	2.6 h	8.6 b-d
WSU 1007	2.8 h	5.1 d
WSU 985	2.8 h	10.6 b-d
Willamette	2.8 h	122.9 a
WSU 991	2.9 h	3.2 d
WSU 994	2.9 h	22.8 b-d

* 0-3 rating scale with 0 = no disease and 3 = numerous rust pustules on primocane leaves. Ratings were made on early-October each year.

** Canes collected in late-February.

Table 2. Change in density of teliospores on canes during the winter.

Month	Teliospore density no./cm^2	% reduction from January sample
January	346 a	--
February	276 ab	20
March	140 b	60

Project No.: 13C-3755-3775

Title: Effect of Water Stress on the Cold Hardiness of Red Raspberry

Personnel: R.L. Hummel and P.P. Moore, Associate Horticulturists
WSU Puyallup Research and Extension Center

Reporting Period: This progress report covers raspberry cold hardiness research conducted during the 1994-1995 winter season.

Accomplishments: Buds and stems of water stressed, container-grown 'Meeker' plants were found to be more cold hardy during deacclimation than the buds and stems of the watered control plants. Measuring the potential for this early season water stress to affect growth and yield of the plants was not a part of this project.

Results: On Jan. 25, 1995, quiescent dormant, container-grown 'Meeker' plants were moved to an unheated screenhouse covered by a fiberglass roof. One half of the plants were kept well watered (control plants) and the other half received no water (water stressed plants). Cool and cloudy weather during the next 7 to 8 weeks kept the growing media from drying out rapidly. By Mar. 28, buds of floricanes were growing. Although new growth gave no visual indication of wilt, on Mar. 28 stem and bud samples were harvested for laboratory determinations of water status and cold hardiness.

Stem water potential was measured with a pressure chamber and stem and growing medium water contents were determined by taking fresh and dry weight measurements and calculating water content on a percent dry weight basis. Cold hardiness of replicated two-bud cane samples was determined in controlled laboratory freezing tests. A Tk_{50}, defined as the temperature at which 50% freeze damage occurred, was calculated for the buds and stems.

The water content of the growing medium as a percentage of dry weight was 291% and 76%, respectively, for the watered controls and water stressed plants. Stem water potentials of watered controls averaged -9.2 bars while water stressed plants were significantly more stressed with an average water potential of -18.5 bars. Stem water contents also indicated plants in the no water treatment were more stressed with 101% water as a percent of dry weight versus 124% for the watered controls.

Freezing test results indicated the deacclimating buds and stems of the water stressed plants were more hardy, by 2.4°C(4.3°F) and 4.3°C(7.7°F), respectively, than buds and stems of the well watered control plants.

Project No.: 13C-3755-3775

Title: Screening Red Raspberry Selections for Cold Hardiness

Year Initiated 1995 **Current Year** 1995 **Terminating Year** 1996

Personnel: Rita L. Hummel, Associate Horticulturist, Patrick P. Moore, Associate Horticulturist, Diane W. Privett, Research Technologist III, Susan Smith, Laboratory Technician I, WSU Puyallup Research and Extension Center

Justification:

Crop loss due to cold damage is a recurring problem for the Washington red raspberry industry. Developing commercially useful red raspberry cultivars that are cold hardy under western Washington conditions is the primary goal of this research.

Cold hardiness in plants is a complex phenomena involving a variety of genetic and environmental factors. The seasonal change in cold hardiness can be divided into 3 components: acclimation, the change from the tender to the cold hardy state that occurs in autumn; ultimate midwinter hardiness, the lowest temperature the plant can tolerate at its maximum cold hardiness level; and deacclimation, the onset and rate of loss of cold tolerance in response to warm temperatures in late winter or spring. Improper development of any one of the cold hardiness components can result in cold damage or plant death. Differences in susceptibility of red raspberry cultivars to winter injury are an indication that the necessary genetic variability exists for improvement of this trait. In breeding for improved cold tolerance and in designing cultural practices to ameliorate cold damage, it is essential to know which cold hardiness component is the weak point in the plant's ability to survive.

This research will be conducted to determine the cold tolerance of red raspberry cultivars and numbered selections in response to western Washington conditions. Our project is focused on cold hardiness evaluation of red raspberry genotypes of interest to the breeding program conducted by Dr. Patrick Moore at WSU Puyallup.

To the best of our knowledge, this project does not duplicate work being done in Oregon or Idaho. In Oregon, cold hardiness research is focusing on blackberries and in Idaho, cold hardiness is being tested only in red raspberry stems. The Idaho climate conditions and cultivars are not the same as western Washington and we are testing both bud and stem cold hardiness.

Objectives:

1. To measure the seasonal change in cold hardiness of field-grown red raspberry selections of potential importance to the breeding program. (This will be completed during the 1995-1996 winter season.)

2. The long-term objective of this research is to develop commercially viable, cold hardy red raspberry cultivars for Washington growers.

Procedures:

Cold hardiness of stems and buds of 10 numbered red raspberry selections (WSU1067, WSU1081, WSU1082, WSU1096, WSU1097, WSU1098, WSU1099, WSU1102, BC85524 and BC851816) and 4 named cultivars ('Chilliwack', 'Chilcotin', 'Meeker', and 'Willamette'), based on availability on of plant material, will be tested in mid-November 1995, mid-January and mid-March 1996. Cold hardiness of two-bud cane sections prepared from 3 plants of each genotype growing in the field at WSU Farm 5 near Puyallup will be determined in controlled laboratory freezing tests. Samples will tested at 3 C intervals and tissue injury determined by the visual browning method. A Tk_{50}, defined as the temperature at which 50% freeze damage occurs, will be calculated for the buds and stem of each cane section from the visual browning data.

Anticipated Benefits and Information Transfer:

The results of this research will provide information concerning the cold adaptation of red raspberry selections that show promise in the breeding program. The potential benefit of this information is that it will help with the development of cold hardy, commercial red raspberry cultivars for Washington growers.

Results of this research will be transferred to growers in Raspberry Commission reports, talks given at the Western Washington Horticultural Association and papers published in the WWHA Proceedings. In addition, articles can be written for the "Berry Basket" and/or the "Northwest Raspberry" publications.

Budget:

Amount allocated by commission for 1994-1995 cold hardiness research: $1,300.00

Request for 1995-1996 cold hardiness research:

Salaries Laboratory Technician I (at 0.14 FTE)	$3,264
Operations	100
Employee Benefits	1,241
TOTAL	$4,605

PROGRESS REPORT FOR THE BRITISH COLUMBIA RASPBERRY BREEDING PROGRAM FROM THE PARC, AGASSIZ AND VANCOUVER SITES 1995 -

Chaim Kempler and Hugh Daubeny

RASPBERRY

The new cultivar, 'Qualicum', which is now being grown commercially in B.C., was outstanding for long distance shipping. Its fruit is firmer than that of 'Tulameen' and larger than that of 'Chilliwack'and shows at least as much resistance to postharvest rot as the latter. Both 'Tulameen' and 'Chilliwack' are recognized for their adaptation to fresh market outlets. Approximately 30,000 certified plants of 'Qualicum' were sold in 1995. It is the first cultivar from the program to be sold under royalty agreements. 'Qualicum' is susceptible to crown gall and this factor has to be taken into consideration in propagation schemes. 'Tulameen' continues to be widely planted; locally it is the preferred cultivar for fresh market. This year it was noted for its lengthy harvest season.

Selection 85-5-24 will be named within the next year; it produces large, brightly colored fruit and appears to satisfy the niche for an early-ripening fresh market type. It will be named 'Malahat'. Two other selections, 85-18-16 and 86-6-15, continue to be propagated for more extensive testing; the former is a late ripening fresh market type and the latter a high-yielding 'Meeker' type adapted to processing.

Six selections were identified in first test plots as probably deserving wide scale testing. However, it was decided to observe each for one more season before giving planting stocks to propagators. Two of these are processing types and the other four are fresh market types.

It is planned to evaluate (or re-evaluate) all the above-selections for reactions to Phytophthora fragariae-incited root rot in greenhouse pots tests (at the Vancouver site) this coming winter. In addition, various species derivatives, from Rubus strigosus, will be evaluated. This work will be done at the Vancouver site in cooperation with Andre Levesque and HAD.

Eight primocane cultivars and selections, planted in 1994, were evaluated. Two selections, from Jan Danek's program in Poland, were the earliest ripening (July 31) and one was a particularly high yielder during August. 'Autumn Bliss' ripened a few days later but produced crumbly fruit. 'Dinkum', 'Polana' and 'Joan Squire' (from Derek Jenning's privately sponsored program in England) began ripening in mid-August; 'Dinkum' had the best quality of any of the cultivars or selections. 'Joan Squire' quality was inferior to that of 'Dinkum' but superior to that of 'Polana', which was the lowest yielder of the three. 'Bogong' (along with 'Dinkum', from Graeme McGregor's program in Australia) also produced fruit of good quality but did not start to ripen until August 22, approximately 8 days before 'Heritage'. However, it was not amongst the higher yielders. 'Heritage' was the only one of the enteries that produced fruit consistently and with an attractive appearance throughout September. It is hoped

that virus-free plants of the extremely ripening 5961/24, (from Vicky Knight's program at East Malling) will be available for planting in 1996; virus-free plants are being propagated by Pat Miller at Sakumas.

Approximately 2,000 seedlings, previously selected for resistance to the common strain of Amphorophora agathonica, the aphid vector the raspberry mosaic virus complex, will be examined for horticultural traits in 1996.

For the second year, Rubus strigosus seed was obtained from various sites throughout North America to be used in the study to determine genetic diversity, via the use of DNA markers, in the species. This is an on-going project in cooperation with John Carlson, Biotechnology Laboratory, UBC, and Brian Ellis, Plant Science Department, UBC.

By this time next year, the raspberry breeding program wil be re-located to the Agassiz site of the PARC (the Vancouver site will be closed). It is hoped that resources at Agassiz will gradually improve and within a few years be comparable to those that now exist at Vancouver. Some of the studies now done in Vancouver, for example screening for root rot reactions, will eventually be done at the Agriculture and Agri-Food Canada site at Summerland. It is anticipated that at least part of the virus indexing work associated with the program will contracted out to Dr. Bob Martin who recently went to Corvallis, Oregon. Obviously there will be some logistic problems in continuing the cooperative work that has been an intregal part of the program.

report prepared November, 9, 1995

PROGRESS REPORT WA RED RASPBERRY COMMISSION

Title: Improving machine harvest efficiency of red raspberries

Personnel: Dr. Bernadine C. Strik, Associate Professor,Department of Horticulture, Oregon State University, Ag & Life Sciences 4017, Corvallis, OR 97331-7304
Ms. Helen Cahn, Research Assistant, NWREC

Reporting Period: 1995-96

Accomplishments/Results:

A field trial of 'Meeker' was established at NWREC in spring, 1993 (see proposal for treatment list). In 1994, there was insufficient growth for a "baby crop". Thus, primocanes were trained as they grew to either a hill system or hedgerow. In 1995, the first data were collected.

We have still not established the full cane density treatments in this planting. Average cane number per plant was 4.7, 8.2, and 9.4 for the 5, 10, and 15 canes/hill treatments, respectively. Obviously, we can expect our results to be affected by this and to perhaps change as we reach our higher cane density treatments.

Cane density and training treatments had a significant effect on total yield, marketable yield, and berry weight (Table 1, Appendix). Training (topped versus looped) and cane density had a significant effect on yield (Figure 1, Appendix). However, only training, not cane number/hill, had a significant effect on berry weight (Figure 1, Appendix). Plants with 5 canes/hill had a lower yield than the other treatments. However, as we did not have much of a difference in cane number between our "10" and "15 canes/hill" treatments this year, we saw little difference in yield between these cane densities (Table 1, Appendix). Berry size was significantly greater on topped canes than on looped canes. Yield per cane declined as cane density per hill increased and in the hedgerow (Figure 2, Appendix). This is probably related to a reduction in flower bud initiation in the thicker canopies of the higher density treatments and hedgerows. It will be interesting to see what happens when we reach higher cane densities.

Percent drop after machine harvest and percent culls were not affected by treatment (Table 1, Appendix). Thus, we did not see greater fruit rot in the hedgerow treatments. Losses to machine harvest drop were less than expected at about 8%, but the planting is still young.

Appendix - Strik: Machine harvest efficiency and production of 'Meeker'

Table 1. **Effect of cane density and training system on yield, berry weight, and machine harvest efficiency of 'Meeker', 1995.**

Treatment[z]	Total Yield (T/A)	Cull (%)	Drop (%)	Marketable Yield (T/A)	Berry Weight (g)
HS 5 T	3.3 a	11.7	7.1	2.7 a	3.25 a
HS 10 T	4.0 abc	9.6	8.2	3.3 abc	2.95 b
HS 15 T	4.3 bcd	8.9	8.6	3.5 bc	3.00 ab
HS 5 L	3.4 ab	10.8	8.9	2.8 ab	2.80 bc
HS 10 L	5.2 d	7.7	7.9	4.4 d	2.93 b
HS 15 L	4.5 cd	9.8	7.1	3.7 cd	2.60 c
HR 6" T	3.9 abc	10.8	9.5	3.2 abc	2.80 bc
HR 12" T	4.4 cd	9.4	9.0	3.6 bcd	2.53 c
Sig.	**	NS	NS	**	***

[z]T = topped canes at 6'; L = entire cane topped; HS = hill system; HR = hedgerow.

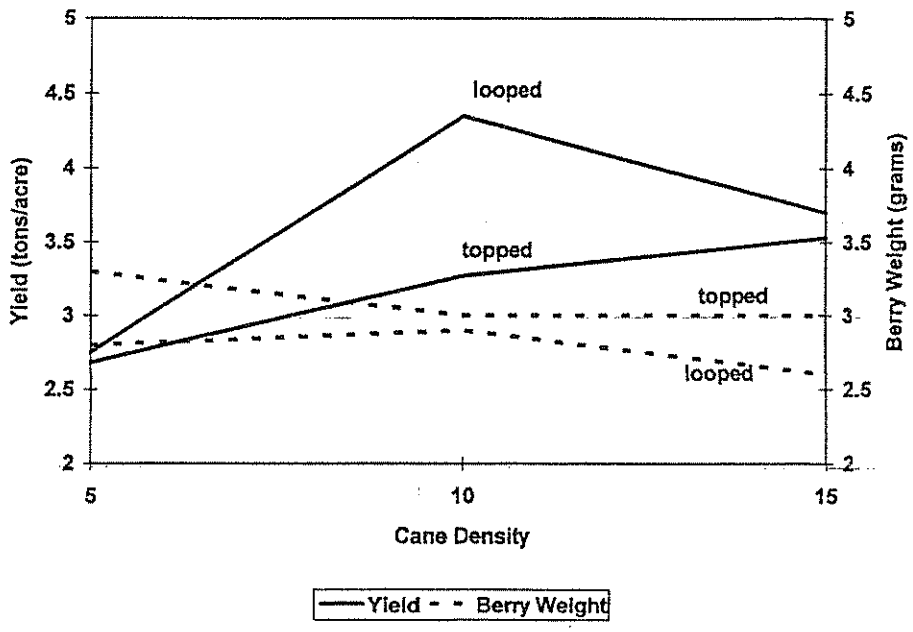

Figure 1. Effect of cane density/training system on yield and berry weight of 'Meeker', 1995

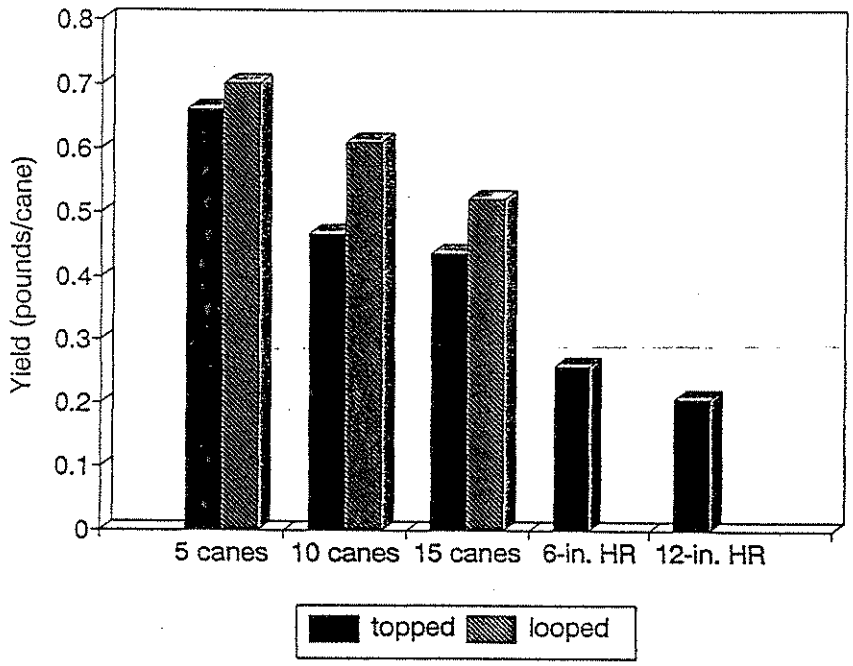

Figure 2. Effect of cane density/training system on yield per cane of 'Meeker', 1995

PROPOSAL: WA RED RASPBERRY COMMISSION--1996-97

Title: Improving machine harvest efficiency and production of red raspberries

Year initiated: 1993; **Current Year:** 1996; **Terminating Year:** 1997-98

Personnel: Dr. Bernadine C. Strik, Associate Professor
Department of Horticulture
Oregon State University, Ag & Life Sciences 4017
Corvallis, OR 97331-7304
Phone: (503) 737-5434

Ms. Helen Cahn, Research Assistant, NWREC

Justification:

The Pacific Northwest (OR and WA) is the leading producer of red rasbperries in the United States with 59 million pounds produced from 9,500 acres in 1994. Over 75% of the red raspberries produced in the Pacific Northwest are machine harvested. Machine harvest is more economical for the grower and produces a better product for processing with better color and higher soluble solids than hand picking.

Average yields of red raspberry in Oregon and Washington are 3.3 tons/acre. This is estimated to be less than **one fourth** of the potential yield that could be achieved through modified cultural practices and increased machine harvest efficiency. Currently about 20 to 25% of the crop is estimated to be lost on the ground during machine harvest. However, actual data have not been collected in a controlled experiment. If yield and machine harvest efficiency could be improved through modified cultural practices, the red raspberry industry could have additional production of at least 5 tons/acre.

Machine harvester manufacturers have improved their equipment, especially over the last 20 years, to increase efficiency of harvest (i.e. increase the percent of ripe fruit harvested). The newer models with a vertical rotary shaker apparatus show promise for increasing harvest efficiency over the horizontal shaker bar machines. Manufacturers however, feel that the cultural systems currently in practice could be modified to increase machine harvested yield.

Essentially all red raspberries in the Pacific Northwest are produced in a hill system with plants grown as individual clumps of canes. Plants are set 2' apart in rows spaced 10' to accommodate machine harvesters.

Growers often thin out canes in each hill at pruning time. The method by which growers train the canes on the trellis is either a bundle with the canes topped at about 6' or looped bundles with the canes un-topped.

It is likely that alternative training, pruning, and cultural systems could increase production as well as machine harvest efficiency.

Evidence indicates that the hedgerow system of production (a solid row of canes) can increase production per unit area by increasing the number of canes per ft^2. Also, a narrow hedgerow would likely increase machine harvest efficiency by allowing the catcher plates of the machine harvester to stay open a uniform distance, thus decreasing chance of fruit loss.

In the hill system, production could also be increased if growers did not thin out healthy canes from the hill at pruning time. However, the effect of larger hills with more canes on machine harvest fruit losses is not known; larger hills may make the catcher plates of the machine harvester stay open longer thus increasing fruit drop to the ground.

An in depth study on comparing the hill and hedgerow systems at various cane densities as well as comparing training systems with regards to machine harvest efficiency and total yield should provide growers with the information necessary to increase red raspberry production. A state-of-the-art machine harvester would be required for this study and plot size would have to be large enough to get a realistic measure of the efficiency of machine harvest for the various treatments.

Objectives:

- Compare the hill and hedgerow production systems and topped and un-topped canes at various cane densities for yield and machine harvest efficiency.

Procedures:

'Meeker', the most widely planted commercial red raspberry in the Pacific Northwest, will be studied. A field trial was established at the North Willamette Research and Extension Center (NWREC) in spring '93.

The experiment consists of 8 treatments and 4 replicates arranged in a completely randomized design. The 8 treatments are as follows: **Hill system: A**) canes topped at 6' (5 canes/hill; cane density .2/ft^2); **B**) canes topped at 6' (10 canes/hill; cane density .4/ft^2); **C**) canes topped at 6' (15 canes/hill; cane density .6/ft^2); **D**) untopped, looped bundles (cane no.= A); **E**) untopped, looped bundles (cane no.= B); **F**) untopped, looped bundles (cane no.= C); **Hedgerow: G**) topped at 6' (6" wide); **H**) topped at 6' (1' wide).

Treatments A through F were planted at a spacing of 2.5' x 10' and G and H at 2' x 10'.

Each of the 32 plots consists of a 20' row of plants with a 10' un-planted section on either side. This allows for a sufficient length of row to machine harvest, but also a non-planted section so that the machine can be "cleared of all fruit" before moving to the next plot. The planting is thus ½ acre in size including guard rows and headland space. The planting was established in 1993.

In 1994, the primocanes were trained as they grew to form the hills or hedgerow. In winter 1994-95, the plots were pruned to the desired cane density -- however, we still haven't achieved our high density treatments (see progress report).

In 1995, fruit were harvested by a Littau machine equipped with a vertical rotary shaker every 2 to 3 days. Data collected per 20' plot at each harvest: pre-harvest fruit dropped on ground (fruit yield lost between harvests); machine harvested yield; post-harvest fruit loss on ground (to calculate machine harvest efficiency); mean berry size (from 25 fruit harvested each date); culls (non-marketable fruit) and total yield.

Data collected at the end of fruit harvest per 5 canes in each plot: number of nodes/cane; number of reproductive nodes/cane (calculate bud break); average lateral length; number of fruit per lateral; cane length; and cane diameter.

Anticipated Benefits:

Growers will have the data to make an educated decision regarding cultural practices (production system, pruning, and training) that optimize yield and machine harvest efficiency.

Results will be shared through articles in industry newsletters and presentations to industry groups.

Budget:

Support in 1993-94: $2,040; 1994-95: $540; 1995-96: $1,500

Request for 1996-97:

Temporary Labor	$2,400
TOTAL	$2,400

No additional support for this project has been received for 1996-97 to date. Support for Research Assistant salary time, pesticides, fertilizers etc (about $9,000) will be requested from the Oregon Raspberry & Blackberry Commission for 1996-97.

Progress Report:
Title: Transformation of Raspberry with the Coat Protein of Raspberry Bushy Dwarf Virus and a herbicide resistance gene

Robert R. Martin, Research Scientist; Kirsten Finstad and Morven McLean, PostDoctoral Research Associates; Agriculture Canada Research Station, 6660 NW Marine Dr. Vancouver, B.C. V6T 1X2, RRM currently at USDA-ARS, 3420 NW Orchard St., Corvallis, OR 97330

Reporting Period: 1995
Accomplishments: Sequence of raspberry bushy dwarf virus coat protein has been completed. Seven varieties of raspberries have been established in tissue culture. Regeneration of Canby has been accomplished, Skeena regenerates in high numbers but the major variety Meeker still has a very low percentage of regeneration.

Results: After considerable effort at developing a regeneration (growing raspberry plants from leaf pieces) method for raspberry cultivars grown in the Pacific Northwest we have met with relatively little success. In the meantime, Agritope of Beaverton, OR have been able to transform raspberry including the variety Meeker. Rather than continue on work that they have accomplished I plan to work with them to transform Meeker raspberry with genes to confer resistance to raspberry bushy dwarf virus (RBDV).

Shoot regeneration has been achieved in Comet and Canby. The level of regeneration is dependent on the quality of the donor leaf material, the presence of various vitamins and other organic media additives, and the choice of cytokinin, thidiazuron being by far the most effective of those tested. Of varieties grown in the Pacific Northwest only Skeena has been regenerated at a high rate. Since Agritope has been able to regenerate Meeker raspberry we will cooperate with them on the transformation aspect of this study so that we can get plants in the field for evaluation as soon as possible.

The coat protein gene of RBDV has been inserted into a cassette containing a suitable promoter and polyadenylation signal and transferred to a strain of *Agrobacterium*.

Project No:

Title: Transformation of Raspberry with the Coat Protein of Raspberry Bushy Dwarf Virus and a herbicide resistance gene

Year Initiated 1993 Current Year 1994 Terminating Year 1998

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

Justification:

After considerable effort at developing a regeneration (growing raspberry plants from leaf pieces) method for rasbperry cultivars grown in the Pacific Northwest we have met with relatively little success. In the meantime, Agritope of Beaverton, OR have been able to transfrom raspberry including the variety Meeker. Rather than continue on work that they have accomplished I plan to work with them to transfrom Meeker raspberry with genes to confer resistance to raspberry bushy dwarf virus (RBDV).

Raspberry bushy dwarf virus (RBDV) is the most common virus disease of raspberries in the Pacific Northwest. Currently, only two raspberry cultivars (Willamette and Chilcotin) grown in this area are resistant to RBDV. Transmission of RBDV is associated with flowering and therefore control is very difficult or impossible by chemical means. With the technology of incorporating specific viral genes or mutated viral genes into plants and the finding that these plants express some form of resistance to subsequent infection by the virus we have the tools required to develop synthetic resistance to plant viruses.

With the decline of Willamette as the major raspberry cultivar in the Pacific Northwest we can expect RBDV to become more of a problem in raspberry plantings. Meeker, which is the most widely planted variety today, is susceptible 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.

Objectives:

1. Develop regeneration protocols for several raspberry cultivars grown in the Pacific Northwest.
2. Clone and sequence the coat protein of RBDV
3. Clone and sequence the movement protein of RBDV.
4. Transform raspberry with coat protein and movement protein genes of RBDV
5. Combine virus coat protein with other traits such as herbicide tolerance.
6. Test transgenic plants for virus resistance, herbicide tolerance and other incorporated traits.

This year we will be addressing objectives 1, 3, 4

Procedures:

This project requires a significant amount of tissue culture for plant propagation and regeneration. Recent work with two plant viruses suggests that movement protein (protein that allows the virus to move from cell to cell in a plant) may be a better target for virus resistance that coat protein. We therefore will clone and sequence the movement protein of RBDV (obj. 3) and put this into raspberry as well as the coat protein and then determine which gives the best level of resistance. When these plants are developed we will also try to have them tested for resistance to the new strain of RBDV in Europe (this will be done in collaboration with colleagues in the UK). The virus coat protein is cloned, sequenced and then transferred to Agrobacterium for transformation experiments. This gene will also be combined with a herbicide tolerance gene. Methods to detect DNA, RNA and proteins will be used to ensure the gene is inserted and to ensure that the gene is functional in raspberry plants.

Anticipated Benefits and Information Transfer:

Virus resistance will increase the life of raspberry plantings, herbicide tolerance to a relatively safe herbicide will reduce the risk to the operator and the environment. 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. If Ignite looks like it may be used as a cane burning chemical then obviously it will not be incorporated into raspberry other than for research purposes. We have been obtained the gene for Ignite resistance and are still trying to get access to the Roundup resistance.

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 1995	4000
Request for 1996	2000
Salaries	1000
Supplies	1000

Moving from Vancouver, B.C. to Corvallis, OR delayed some of the research in this project. As a result I am requesting less funds than I did last year as we only used about 1/2 of last years money.

Project No.: 13C-3761-6784

Title: Biology and importance of a cane dieback disease

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

Reporting period: 1995

Accomplishments: Field experiments for 1995 were postponed until 1996 when we discovered that the cultures to be used for inoculation were contaminated. However, in the laboratory we were able to investigate the influence of temperature and growth medium on mycelial growth, spore germination and spore production. This was a first attempt to better understand how the environment affects this cane pathogen.

Results: *Siematosporium lichenicola*, the fungus causing cane dieback, grew at temperatures up to 30°C (87°F) with an optimum of 20°C (68°C). The fungus continued to grow when the temperature was just above freezing but the rate was extremely slow. Spores (conidia) were produced between 15 and 30°C (59-87°F). Light (white or ultra violet) was needed for spore production. Spores readily germinated on a number of growth media including water agar. Germination on water agar suggests that spores can germinate in a low nutrient environment. Under optimum conditions spores germinated (produced at least one germ tube) in about 9 hours. Individual spores consist of 4 cells and each was able to germinate. Over time each cell produced multiple germ tubes. The basal cell contains less pigment than the other three cells and was the least likely to germinate. Spores are disseminated by splashing water so inoculum is readily transferred to young primocanes as they grow up through infected fruiting canes.

Project No.: 13C-3761-6784

Title: Biology and importance of a cane dieback disease

Year Initiated: 1995 **Current Year:** 1996 **Terminating Year:** 1997

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

Justification: The fungus *Coryneum ruborum*, was reported to be widespread on canes of both red and black raspberry in western Oregon during the 1920's. Brown lesions were noticed in the fall on primocanes. The following spring the fungus would produce spores on the surfaces of infected fruiting canes. The areas of sporulation became ashen. In general little damage has been associated with this disease even during the occasional outbreak. The fungus is now called *Siematosporium lichenicola* and it was associated with a severe dieback of red raspberry in Clark County in 1994. The grower involved reported seeing symptoms for a couple of years before then. In spring, the bark on infected canes was tan and shriveled, but later it peeled away along longitudinal and circumscribing cracks giving the canes a shaggy appearance. Few buds on infected canes grew into laterals and many infected canes were killed with a total loss of production.

Based on symptoms and sporulation this disease can be readily distinguished from several other cane diseases including, cane Botrytis, spur blight, anthracnose and cane blight.

It has been suggested that the pathogen causing this dieback disease infects only after low temperature injury. An outbreak after the mild winter of 1993-94 does not support this idea. The effect of the fungus on plant growth, yield and fruit quality is not known and the importance of the disease is poorly understood. Little research has been conducted on this cane disease. Clean cultivation and a dormant lime-sulfur application historically have been recommended for control but it is unknown if either were effective.

Objectives:

1. Determine if the fungus can attack primocanes directly or if canes must first be wounded.

2. Determine when primocanes are susceptible.

3. Determine if liquid lime-sulfur or other fungicides which might be applied to red raspberries in the spring prevent

spore germination.

Procedures:

Agar plugs containing the fungus will be used to inoculate non-wounded and wounded primocanes and petioles on primocanes. Petioles will be inoculated because lesions develop primarily at nodes, suggesting that infection may occur through petioles or leaf scars. Primocanes will be inoculated at different times during the growing season to find out when they are susceptible. Inoculated canes will be followed through to the fruiting year to estimate the damage caused by the disease. A nutrient medium that supports spore germination will be amended with different concentrations of several fungicides, including liquid lime-sulfur, to see which chemicals the fungus is sensitive to.

Anticipated Benefits:

Like yellow rust, this cane disease may be reappearing because the industry has moved away from certain culture practices and the use of liquid lime sulfur as a dormant application. The results of this study should determine when infection occurs, which will be useful in timing fungicide applications for control. If infection is favored by wounding or wounds are actually required for infection, this will be important information for growers who harvest by machine.

New information from this project will reach growers through annual progress reports and presentations at grower meetings.

Budget:

Amount allocated for FY 1995-96: $1,498. Because much of the proposed research was postponed until the 1996 crop year, only $580 was spent on the project for FY 1994-95.

Request for FY 1996-97

Salaries	
Time-slip labor	$ 300
Operations	100
Travel	82
Projected Needs	
Meetings	50
Other	
Equipment	
Employee Benefits	48
Total	$ 580

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

Personnel

Dr. Thierry C. Vrain, Principal Investigator.
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Dr. Dominique Michaud, postdoctoral fellow (biochemistry).
Dr. Daniel Petersen, postdoctoral fellow (molecular biology).
Dr. Martine Korban, postdoctoral fellow (genetic transformations).
Ms Susan Wahlgren, technician (tissue culture).
Dr. David Raworth, collaborator AAFC (entomology).

Reporting period 1995

Accomplishments

The proteinase activity of black vine weevils (BVW) and twospotted spider mites (TSM) were characterized biochemically. Genes coding for OCI and OCII, two rice cystatins, have been cloned. Both pests utilize cysteine proteinases sensitive to rice cystatins, OCI and OCII. Transformation vectors with OCI driven by a 35S promoter have been constructed, and introduced into *Agrobacterium tumefaciens*.

Results

The objectives of the first year of this project were partially accomplished and the results are published or in press. Insects, mites and nematodes were raised and/or collected. Digestive proteolytic enzymes were studied using biochemical techniques (polyacrylamide SDS/gelatin activity gel electrophoresis, and azocasein proteolysis tests). BVW and TSM utilize a fairly simple system of cysteine proteinases, one single form for TSM and five isoforms for BVW. *In vitro* digestive activity by these enzymes was inhibited completely by OCI in TSM, and partially in BVW. Proteolytic enzymatic activity of root lesion nematodes could not be measured using standard techniques, whereas we were able to study that of other nematodes. We are proceeding with the assumption that root lesion nematode have mainly serine or cysteine proteolytic enzymes.
Raspberry cv Comet were established in tissue culture and are ready for genetic transformation with *Agrobacterium*.

Current publications

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Robbins, R.T., D.J.F. Brown, J.M. Halbrendt, and T.C. Vrain. 1995. Compendium of *Longidorus* juvenile stages with observations on *L. pisi, L. taniwha*, and *L. diadecturus*. *Systematic Parasitology* 32: 33-52.

Wendt, K.R., A. Swart, T.C. Vrain, and J.M. Webster. 1995. *Ditylenchus africanus* sp. nov. from South Africa; a morphological and molecular diagnosis. *Fundamental and Applied Nematology* 18: 241-250.

Michaud, D., L. Cantin, D. Raworth, and T.C. Vrain. 1995. Assessing the stability of cystatin/cysteine proteinase complexes using mildly-denaturing gelatin-polyacrylamide gel electrophoresis. *Electrophoresis* (In Press).

Michaud, D., B. Nguyen-Quoc, T.C. Vrain, D. Fong, and S. Yelle. 1995. Cystatin-insensitive proteinases in Coleoptera. *Insect Biochemistry and Physiology* (In Press).

Michaud, D., T.C. Vrain, V. Gomord, and L. Faye. 1996. Stability of recombinant proteins in transgenic plants. Methods in Molecular Biotechnology, *The Production of recombinant proteins in plants*. C. Cunningham and A. Porter, eds. Humana Press, Totowa NJ (In Press).

Michaud, D., and T.C. Vrain. 1996. Production of proteinase inhibitors in transgenic plants. Methods in Molecular Biotechnology, *The Production of recombinant proteins in plants*. C. Cunningham and A. Porter, eds. Humana Press, Totowa NJ (In Press).

Vrain, T.C., T. Forge, R.M. De Young. 1996. Seasonal changes in *Pratylenchus penetrans* populations in relation to root growth of raspberry. *Fundamental and Applied Nematology* (In Press).

Vrain, T.C. 1995. Pathogenicity of Pratylenchus penetrans to American Ginseng. TAGG Times 3 (1): 2-6.

Michaud, D., and T.C. Vrain. 1995. Characterization of endoproteases from the root-knot nematode, *Meloidogyne hapla*. 1994 BC Region Annual Meeting of the Canadian Phytopathological Society. Vancouver, BC, 20-21 October. Canadian Journal of Plant Pathology (In Press).

Michaud, D., T.C. Vrain, and H.A. Daubeny. 1995. Potential of plant cystatins for the production of transgenic strawberry plants resistant to the black vine weevil, *Otiorynchus sulcatus*. (Abstract, 92nd Annual Meeting of the American Society for Horticultural Science, Montréal, PQ, July 30-August 2). Hortscience 30: 828.

Vrain, T.C., D. Michaud, L. Cantin, M. Bonade-Bottino, and L. Jouanin. 1995. Cystatin-sensitive proteinases in *Meloidogyne hapla*. (Abstract, 34th Meeting of the Society of Nematologists, Little Rock, AK, August 4-9). Journal of Nematology 27: (In Press).

Vrain, T.C., L. Cantin, and D. Michaud. 1995. Choosing proteinase inhibitors to control nematodes. (Abstract, 34th Meeting of the Society of Nematologists, Little Rock, AK, August 4-9). Journal of Nematology 27: (In Press).

Michaud, D., T.C. Vrain, D.A. Raworth, and H.A. Daubeny. 1995. Pest control using proteinase inhibitors: is it compatible with IPM strategies? (Abstract, 92nd Annual Meeting of the American Society for Horticultural Science, Montréal, PQ, July 30-August 2). Hortscience 30: 801.

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

Personnel

Dr. Thierry C. Vrain, Principal Investigator.
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Dr. Dominique Michaud, postdoctoral fellow (biochemistry).
Dr. Daniel Petersen, postdoctoral fellow (molecular biology).
Dr. Martine Korban, postdoctoral fellow (genetic transformations).
Ms Susan Wahlgren, technician (tissue culture).
Dr. David Raworth, collaborator AAFC (entomology).

Justification

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

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

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

Objectives

This research project will develop transgenic red raspberry plants resistant to the black vine weevil, twospotted spider mites, and to the root lesion nematode. We are adapting a novel approach to the control of insect and nematode pests, engineering the production of proteinase inhibitors from other plants into transgenic raspberry plants.

The objective of the second year of this research project will be to regenerate transgenic raspberry plants cv Comet expressing OCI, a cystatin from rice, and CII, a serine proteinase inhibitor from soybean. After molecular characterization, the plants will be multiplied and transferred to a greenhouse. In the third year, the plants will be assayed for levels of pest resistance against twospotted spider mites, black vine weevils, and root lesion nematodes.

Procedures

Transformation and regeneration of resistant transgenic raspberry plants. This will involve techniques of genetic engineering, molecular biology, tissue culture. The binary transformation vectors containing the proteinase inhibitor genes driven by a constitutive (35S) promoter were introduced into disarmed *Agrobacterium tumefaciens*. Raspberry leaf tissue will be inoculated using standard published procedures. Transformed calli will be cultured and shoots will be rooted on appropriate media.

Regenerated transgenic seedlings will be checked for the presence of the proteinase inhibitor genes using PCR (polymerase chain reaction), and for gene copy number by Southern blotting. The levels of gene expression will be evaluated by Northern blotting. Plants with a high level of transgene expression will be transferred and acclimated to greenhouse conditions before bioassays with pests.

Anticipated Benefits

1. Genetic resistance against the black vine weevil, twospotted spider mites, and the root lesion nematode will significantly decrease the losses to this crop and *minimize or eliminate the use of some insecticides, miticides and soil fumigants* to control these pests. **2.** The expression of proteinase inhibitors in transgenic raspberry will have no negative effects on natural predators of the targetted pests. **3.** It is expected that the engineered resistance to these pests might introduce a measure of resistance to other pathogens and stressors, thereby increasing the general health of the crop and decreasing the need for fungicides or other pesticides. **4.** Because we can engineer raspberry cultivars that are presently in use in the Pacific Northwest, this project will result in the licensing of new, resistant or tolerant, cultivars already adapted to Pacific Northwest growing conditions.

Budget:

Salary of tissue culture technician	$ 5,000
Material and supplies	$ 600
Travel	$ 400
Total US	**$ 6,000**

Other support 1995-1996

Science Council of British Columbia	$ 10,000
Oregon Rasberry and Blackberry Commission	$ 10,000
Matching Investment Initiative (AAFC)	$ 3,000

Project No:

Title: Construction of large heat chamber for thermotherapy of caneberry and strawberry plants for virus elimination

Personnel: **Chad Finn,** Research Geneticist, Project Leader, USDA-ARS, Northwest Center for Small Fruit Research, Ted Mackey, Research Technician, Kirsten Wennstrom, Research Technician Tom Garbacik; Facilities Manager, USDA-ARS, Corvallis

Reporting Period: 1995

Accomplishments:

Plans have been drawn up. Material needs have been itemized. Facilities Manager is in process of figuring out how we can do this without going through typical government bidding procedures.

Results:

See Accomplishments

Publications

Not applicable

Current Support (expires 3/96)

Title of Project	Total $ Amount	Granting Surce
Trials Of Entomopathogenic Fungi Against Root Weevils In Strawberry	3980	Washington State Strawberry Commission
Biological control agents against the black vine weevil	4080	Washington State Cranberry Commission
Survey of Oregon cranberry bogs for entomopathogenic fungi which suppress the black vine weevil	2000	Oregon Cranberry Growers Association

PROJECT NO.: Renewal\New **Note:** This proposal merges the activities of 13C-3543-7960 (Tanigoshi) and 13C-3555-4784 (Cameron), projects to have expired in 1996.

TITLE: **TWOSPOTTED SPIDER MITE RESISTANCE: BIOLOGICAL BASIS, GERMPLASM SCREENING AND INCORPORATION INTO RED RASPBERRY BREEDING**

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

PERSONNEL:

Co-Principal Investigators: **Lynell K. Tanigoshi**, Associate Entomologist, WSU Vancouver
J. Scott Cameron, Associate Horticulturist, WSU Vancouver
Patrick P. Moore, Associate Horticulturist, WSU-Puyallup

Investigators: **Steven R. Booth**, Research Associate
Chuhe Chen, Research Associate
Stephen F. Klauer, Research Associate
Washington State University REU, Vancouver

Cooperator: **Arthur L. Antonelli**, Extension Entomologist, WSU-Puyallup

JUSTIFICATION: The twospotted spider mite, *Tetranychus urticae*, is a common problem for red raspberry producers. Feeding by this pest can damage leaves and canopies to the 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. Predators such as *Stethorus punctum picipes*, can control mite numbers, but this predator's numbers are reduced by the use of insecticides or natural events and mite populations can increase drastically. Red raspberries appear to be able to tolerate some mites so that even a moderate level of resistance by the plant combined with some degree of tolerance would be of great value. While there still is a need for chemical insecticides (as few are currently registered), this approach should greatly reduce or eliminate the need for chemical miticides. Aggressive miticide testing will continue in Dr. Tanigoshi's program.

Two clones of *Rubus*, *R. parvifolius* 'Cherry' and 'Dormanred' (*R. parvifolius* x 'Dorsett') were found to be very resistant to mites two years ago. In 1993, an advanced selection of red raspberry that was already in 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 progress in the United States or perhaps the world.

Our purpose is to meaningfully integrate the activities of the entomology, horticulture and breeding programs at Vancouver and Puyallup for this work so that more rapid and meaningful progress can be made. Until we understand the nature of the resistance and tolerance we are breeding for, we will continue to generate large populations of plants which will continually need to be screened in a time and resource-consuming manner. 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 efficient and productive. Dr. Shanks' program, and now Dr. Tanigoshi, has made substantial progress in identifying resistant native germplasm and breeding selections. Dr. Cameron's program has made considerable progress in understanding the physiological impact of mite feeding and has identified differential responses in the available germplasm. Dr. Moore will continue to generate crosses from resistant parents to be screened. Drs. Tanigoshi and Cameron's programs will cooperatively examine the basis of resistance and tolerance with a unique and comprehensive approach, while Dr. Antonelli will provide valuable field expertise and enhance the project's connection with industry through WSU Cooperative Extension.

OBJECTIVES:

1. Continue testing series of crosses made with resistant parents.
2. Continue to collect and evaluate native *Rubus* clones for resistance.
3. Using resistant (WSU 968) and susceptible ('Willamette') standards, study the nature of resistance.
4. Study the nature of tolerance to twospotted spider mite feeding.
5. Identify traits or markers associated with resistance\tolerance.
6. Initiate studies in the development of a bioassay.
7. Use resistant and tolerant germplasm in breeding program.

PROCEDURES:

Objective 1.

Advanced Screening. All resistant *Rubus* clones from the replicated greenhouse screening in 1995 should be tested against both the twospotted spider mite, *Tetranychus urticae*, and the yellow spider mite, *Eotetranychus carpini*, because the two species may affect different clones in different ways. These include clones such as `Dormanred', `Cherry', WSU 968, WSU 822, WSU 1049 and St. Regis (Ranere).

Replicated Secondary Screening. In 1994, 159 red raspberry seedlings that had WSU 968 (spider mite-resistant) and WSU 530, WSU 991, Brandywine, or Schonemann as parents were tested for resistance to spider mites. Those which had <25% as many mites as `Willamette' (mite-susceptible) were planted in the field at WSU-Vancouver in March 1995. There are 66 seedlings plus the above four parent

clones plus `Willamette' (susceptible check). All are replicated four times. They will be sprayed with a pyrethroid insecticide in June 1996 to remove mite predators and spider mites will be counted when numbers are high enough. The seedlings will also be observed for fruit quantity and quality.

Primary Field Screening of Seedlings. WSU 968 was crossed with `Cherokee', `Sunrise', `Meeker', `Chilliwack', `Glen Ample', `Nootka', `Tulameen', WSU 1024, WSU 1027, and WSU 994 in 1994. A total of 921 seedlings from those crosses plus `Willamette' were planted in the field at WSU-Vancouver in 1995. They will be sprayed with a pyrethroid and mites will be counted in 1996 as described for the previous group of seedlings.

Establishment of New Seedling Population. A series of new crosses from resistant parents were made in Puyallup in 1995 which should generate 900-1000 seedlings for screening in 1997. These will be established primarily at one location with extra seedlings from the crosses being placed at both.

Objective 2

Native *Rubus* clones are being collected and planted in Vancouver for screening. There are large collections of various species in the Pacific Northwest and it is this material which will be incorporated into field trials.

Objectives 3, 4, & 5

Concentrating on WSU 968 as a resistant standard, and 'Willamette' as a susceptible standard, anatomical, biochemical and physiological analyses will be used to elucidate the mechanism of resistance so that it can be screened for in a more efficient manner. Anatomical analyses have already been initiated at Vancouver and will continue, comparing cross-sectional and surface anatomy. Within several months we will have an electron microscope and will be able to look at feeding interactions on leaves using high levels of magnification. With regard to tolerance, we will continue ongoing analyses to determine the key factors involved. For example, WSU 968 appears to be photosynthetically more efficient than 'Willamette' and have greater levels of chlorophyll on a dry weight basis and higher levels of photochemical efficiency. It is possible that more chlorophyll and\or a larger number of photosynthetic reaction centers may act as a buffer against mite feeding damage. These types of traits or markers would not be difficult to screen for in a rapid and efficient manner. Similarly, we will run protein assays using polyacrylamide gel electrophoresis (PAGE) to compare protein profiles in mite attacked and uninfested leaves to look for biochemical differences which may be associated with resistance or tolerance.

Objective 6

Screening for resistance in the field and greenhouse is time consuming and labor intensive. In an effort to find ways to screen for resistance without having to directly evaluate large numbers of plants, alternative methods such as leaf disk bioassays will be investigated. Promising techniques would be tested for efficacy against standard methods requiring mite counts on multiple, whole leaflets. In conjunction with studying the plant's response to feeding, it is also important to consider the potential effects of feeding on the pest (reduced fecundity, shortened lifespan, feeding preference, etc.). By understanding both the plant and pest response to feeding, the relative importance of resistance and tolerance in the system can be established.

Objective 7

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

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

The programs involved in this project already have made progress in developing a pool of resistant germplasm and in beginning to understand the response of red raspberry to mite feeding. The use of mite-resistant cultivars would greatly reduce the need for miticides. The team of scientists involved in this project is unique in its background and training, and thus is able to integrate entomology, physiology, horticulture and genetics in a team approach to make this process more efficient and productive. This will allow more rapid progress in developing of resistant varieties.

Results of 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:

		1996
01	Temporary employees	$6,900
03	Supplies and Services	1,200
04	Travel (Industry meetings & Presentations)	300
07	Employee benefits (16% of 01)	1,100
TOTALS		$9,500

CURRENT AND PENDING SUPPORT: *WA RRC denotes WA Red Raspberry Commission*

L. K. Tanigoshi	USDA, 3783	$41,000	9\1\92-8\31\97	Alt control strategies for pests of small fruits
L. K. Tanigoshi	WA RRC, 7960	$ 5,000	1\1\94-12\95	Spider mite management on red raspberries
J. S. Cameron	WA RRC, 4883	$ 4,000	1\1\94-12\95	Mite feeding\miticides - growth\physiology

Project No: New

Title: Rapid Evaluation Of Raspberry Plant Nitrogen Levels and Effect of Nitrogen Fertilizer on Cold Hardiness

Year Initiated 1996 Current Year 1995 Terminating Year 1998

Personnel: Carol A. Miles, Ph. D, WSU Cooperative Extension, Tom Peerbolt, Peerbolt Monitoring Inc., and Rita Hummel, Ph. D., WSU Puyallup

Justification: The Minolta SPAD 502 Chlorophyll Meter is a rapid (3 seconds per reading) method of sampling plant nitrogen status in the field. The SPAD (Soil Plant Analysis Development) meter gives a reading in SPAD units which, through research calibration on nitrogen plots, can be related to actual plant nitrogen levels. The SPAD meter has been used extensively on rice and corn for many years with good results. It has never been tested on raspberries.

Calibrating the SPAD meter for raspberries would allow growers to measure plant nitrogen status in the field without collecting or analyzing leaf samples. Also, a better understanding of the effects of timing of N-fertilizer application on raspberry yields, primocane growth, and cold hardiness will help growers to determine best N-fertilizer management practices.

Objectives: For a two-year period, 1996-97 and 1997-98:

1. Measure SPAD readings and actual leaf nitrogen content.
2. Calibrate SPAD meter for red raspberries.
3. Determine impact of nitrogen fertilization regimes on cane and fruit quality, and yield.
4. Determine impact of nitrogen fertilization regimes on cold hardiness.

Procedures: Four nitrogen plots will be established in a randomized complete block design with 4 replications in the spring of 1996 on a commercial red raspberry field of cv. Meeker. The nitrogen treatments are:

1. 50 lbs N (actual) - 25 lbs in the spring, 25 lbs early summer (check plot)
2. 25 lbs N - spring (low N plot)
3. 75 lbs N - 25 lbs spring, 25 lbs early summer, 25 lbs post harvest
4. 100 lbs N - 25 lbs spring, 25 lbs early summer, 25 lbs post harvest, 25 lbs fall

SPAD readings and leaf samples of both floracanes and primocanes, as appropriate, will be measured once a month throughout the growing season. Leaf samples will be analyzed for nitrogen content at a commercial laboratory. SPAD readings and actual leaf nitrogen contents will be compared for correlation. Plant yield, fruit weight, and fruit mold susceptibility will be measured within the plots to better understand the impact of the split nitrogen application on these yield components. Primocane length or diameter, primocane density, time of dormancy, and cold

hardiness will be measured for each treatment to determine the impact of post-harvest nitrogen application on these growth responses.

Anticipated Benefits: A rapid field test for plant nitrogen content will assist growers in planning their nitrogen fertilizer schedule. A better understanding of the effects of timing of N-fertilizer application on raspberry yields, primocane growth, and cold hardiness will also help growers to determine best N-fertilizer management practices.

Budget: Requested for FY 1996-97

Time-slip labor		$1500
Laboratory analyses		2500
Equipment		200
Travel		800
Employee benefit (16%)		240
	Total	$5240

Matching Funds: Provided by WSU Cooperative Extension Lewis County

Minolta SPAD Chlorophyll Meter	$1310

PROJECT NO.: New

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.

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

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 which 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 which 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 will be established at WSU Vancouver in 1996. 'Meeker', 'Qualicum', 'Tulameen' and 'Willamette' will be included as standards. BC 85-5-24, BC 85-18-16, and BC 86-6-15 will be included if plants are available. NY-7, a new release from the Cornell

program which is supposed to be root rot resistant will be included. Glen Ample was among the highest yielding clones in the planting established in 1992 at Vancouver, Puyallup and Mt Vernon. It will be included in the new planting along with three other cultivars released from the Scottish program at the same time, 'Glen Magna', 'Glen Shee' and 'Glen Rosa'. The highest yielding selections from the 1992 and 1993 yield plots at Puyallup will be propagated for this planting. The planting will total 20-25 clones.

2. The plantings established at WSU Vancouver in 1996 will be harvested for yield, fruit weight, fruit rot, and harvest season.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

New raspberry cultivars that are more productive or more pest resistant will be developed by this program. Such cultivars may result from crosses made this year or may already be under evaluation. 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 maintainence and harvest of raspberry plots at WSU Vancouver. Travel would be to local grower meetings and to research plots.

01 Timeslip labor	2,400
03 Service and supplies	200
07 Benefits (16% of 01)	384
Total	$2,984

PROJECT NO.: New

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: 1996
TERMINATING YEAR: 1997

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 which 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 which 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 will be established at WSU Mt. Vernon in 1996. 'Meeker', 'Qualicum', 'Tulameen' and 'Willamette' will be included as standards. BC 85-5-24, BC 85-18-16, and BC 86-6-15 will be included if plants are available. NY-7, a new release from the Cornell

program which is supposed to be root rot resistant will be included. Glen Ample was among the highest yielding clones in the planting established in 1992 at Mt. Vernon. It will be included in the new planting along with three other cultivars released from the Scottish program at the same time, 'Glen Magna', 'Glen Shee' and 'Glen Rosa'. The highest yielding selections from the 1992 and 1993 yield plots at Puyallup will be propagated for this planting. The planting will total 20-25 clones.

2. The plantings established at WSU Mt Vernon in 1996 will be harvested for yield, fruit weight, fruit rot, and harvest season.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

New raspberry cultivars that are more productive or more pest resistant will be developed by this program. Such cultivars may result from crosses made this year or may already be under evaluation. 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 maintainence and harvest of raspberry plots at WSU Mt Vernon. Travel would be to local grower meetings and to research plots.

00 Salaries	
(Research Tech. I, Mt Vernon)	3,411
01 Timeslip labor	2,400
03 Service and supplies	200
07 Benefits	
(33% of 00)	1,126
(16% of 01)	384
Total	$7,521

Project No.: New

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

Year Initiated 1996 **Current Year** 1996 **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:

Root rot caused by the soil-borne fungus *Phytophthora fragariae* var. *rubi* (formerly *P. erythroseptica*) is the most serious root disease of red raspberry in the Pacific Northwest. While the disease is more common in heavier soils with poor drainage it also occurs on sites with sandier soils. Since 1982, red raspberry growers in the region have been able to use the fungicide Ridomil (metalaxyl) for disease control. This chemical has been effective in established plantings as well as in newly planted fields. More recently the fungicide Aliette received registration for this use but field trials found it to be less effective than Ridomil and limited to use in established fields. Despite these limitation, its use should help to reduce the risk of the pathogen developing resistance to Ridomil.

Identifying genotypes and eventually developing varieties with resistance to the disease continues to be a major objective of the red raspberry breeding programs in the region. However, such varieties are not yet available. Recent research, funded by the Commission, showed that the yield of even the most root rot resistant genotypes increased when they were treated with Ridomil. It now appears that the fungus has become resistant to Ridomil in some fields. In 1995 there was evidence of resistance in a few sites in Oregon plus in plots at one of our research farms near Puyallup. Resistance to Ridomil is known to occur for pathogens of other crops. Alternatives to Ridomil must be found for sites where the fungicide no longer controls this root disease.

Objectives:

1. Test several newer fungicides for control of this root rot under field conditions.

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

Procedures: A replicated field planting will be established at the WSU-Vancouver Research and Extension Center where the soil is naturally infested with *P. fragariae* var. *rubi*. Treatments will begin at planting or as soon as foliage is present for those chemicals which must be absorbed by the leaves. Treatments will include an untreated check and two fungicide standards (Ridomil and Aliette).

The pathogen will be isolated from plants at locations where Ridomil has been used but no longer appears to be providing control. Isolates of *P. fragariae* var. *rubi* obtained will be tested in the laboratory for their sensitivity to Ridomil. They will also be tested against other members of the phenylamide group of fungicides (example, oxadixyl) to look for cross-resistance.

Anticipated Benefits and Information Transfer: Identification and ultimate registration of a new fungicide will give growers a tool to not only control the disease where there is resistance but also to help lower the risk of resistance developing in fields where it has not already appeared. This will also buy additional time for the development varieties with resistance.

Information from this research will be used to support a request to the IR-4 program to fund field research to collect the residue data required for registration. Information on resistance and the use of any newly registered fungicide will be transferred to growers at field days, association meetings and via newsletters or special announcements.

Budget:

Amount allocated by Commission for FY 1995-96. None, new project.

Requested for FY 1996-97

Salaries	
Timeslip	$3,000
Operations	1,900
Travel	
Projected needs	500
Meetings	200
Other	
Equipment	250
Employee benefits	480
Total	$6,330

Other support of project:

Current & Pending Support

INSTRUCTIONS:

Project leaders often request support for a research project (proposal) from more than one source. Provide information as indicated below so potential funding groups can understand the total needs.

Title of Project	Total $ Amount Received for 1996-97.	Granting source from which funding has been approved.
Title of Project	**Total $ Amount Requested for 1996-97.**	**Granting source to which proposal has been or will be submitted.**
Evaluating new fungicides for control of Phytophthora root rot and testing of the pathogen for resistance to Ridomil and related compounds	$3,000	Various fungicide manufacturers whose products will be in this initial field trial.

A:callstra.95.cap/cm
10/95

Project No.: New

TITLE: The Potential of Entomopathogenic and Microbial Biopesticides to Suppress Root Weevils in Red Raspberry

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

PERSONNEL:

Steven R. Booth, Entomologist, Washington State University
Research & Extension Unit, Vancouver, WA 98665-9752

Lynell K. Tanigoshi, Associate Entomologist, Washington State University
Research & Extension Unit, Vancouver, WA 98665-9752

JUSTIFICATION:

Entomopathogenic (insect parasitic) nematodes, fungi, and insecticidal microbes (*Bacillus thuringiensis* (*B.t.*)) offer a biorational alternative to conventional chemical techniques for the management of root weevils in Pacific Northwest small fruits. Entomopathogenic nematodes (Biosafe®, Biosys©), for example, are part of the root weevil management program in Pacific Northwest cranberries, but have not been as effective in other crops due to incompatible soil conditions, poor application techniques, and/or problems with shelf-life and survival during shipping. In addition, the arsenal of entomopathogenic agents has been quite limited to the Biosafe® product.

However, several new strains and formulations of biopesticides are becoming available for both research and implementation. Strains of nematodes with superior searching skills are available from Ecogen© and Nematec©. Mycotech© has formulated and is currently investigating the efficacy of the entomopathogenic fungus *Beauvaria bassiana* against subterranean weevil larvae in citrus and pecan. A novel *B.t.* with demonstrated ability to kill beetle larvae is under development by Myogen© and may be available for field trials by next spring.

Furthermore, red raspberry cultural practices more amenable to microbial biopesticides are currently being implemented. Drip-line irrigation systems, for example, may offer both an effective delivery system and stabilize soil moisture. Manure composts might enhance soil moisture, increase soil temperature, and promote the development of entomopathogenic fungi.

Investigations of the interaction between composted manure and entomopathogenic nematodes and fungi could prove especially rewarding. Although strains of entomopathogenic fungi have been described as selectively killing insect groups, some evidence suggests they may develop, for at least partial generations, on other soil invertebrates. Can entomopathogenic fungi kill nematodes, thus hinder suppression of weevil larvae? Can entomopathogenic nematodes applied to red raspberry during early summer provide some weevil suppression, then act as secondary hosts for later applications of entomopathogenic fungi? In short, can entomopathogenic nematodes and fungi be applied at times and rates so as to create a sustainable weevil suppression system?

OBJECTIVES:

1) Test applications of entomopathogenic nematodes, entomopathogenic fungi, and new commercial brands of *Bacillus thuringiensis* against root weevil larvae in red raspberry. Strains of entomopathogenic nematodes will be compared not only for efficacy against weevil larvae, but also for their ability to move through and persist within the soil.

2 Compare field application techniques for entomopathogenic nematodes. These include application by irrigation drip line and innovative techniques involving mechanical injection and/or shanking. Experimental factors include nematode and fungal survival in red raspberry plots managed with and without manure composts, and nematode distribution and abundance along the drip line.

3) In the laboratory, measure the interaction between entomopathogenic nematodes and fungi when applied to sterile and composted soil at different times and rates.

PROCEDURES:

Field Trials:

1) Comparison of nematode strains with dripline application

Commercial fields which are highly infested with root weevils will be targeted. Nematodes of three or four different strains (e.g., *Steinernema carpocapsae* (Biosafe®, Biosys©), *Heterorabditis bacteriophora* (Cruiser®, Ecogen®) and *H.b.*-strain HP88 (Bioexcel®, Nematec®) will be applied at the same rate through the subsurface drip line. Each strain will be replicated four times with a full row serving as a replicate. Nematodes will be pumped into the drip line of each row. Nematode infestation and movement will be measured by treating soil cores, taken at regular spacings along the rows, with waxmoth larvae, which act as a bait for the nematodes. Application will be made during mid-May, when root weevil larvae are in late-larval or pupal life stages.

2) Comparison of entomopathogenic and microbial agents by innovative techniques

Some of these trials may be conducted at the Washington State University Research Unit at Vancouver, where we have the opportunity to assure high pest pressure and destructively sample several plants. Treatments will consist of two nematode formulations (Biosafe® and Cruiser©), each applied at three rates, an entomopathogenic fungi (Mycotech©), a coleopteran-active *B.t.* (Mycogen©), and an untreated check. Each treatment will be applied to four adjacent plants with a four plant buffer allowed between treatments to comprise an experimental block of 144 adjacent plants. Treatments will be randomized within five blocks. All formulations will be applied during late spring. Efficacy will be measured the following spring by counting surviving black vine-weevil larvae in soil samples.

Biopesticides will be applied in association with manure composts, but specific application techniques are under innovation. Herbicide injectors may be modified to accept a manure/nematode slurry. Shanking techniques may also be employed. We will conduct preliminary research this winter to guide us in this regard.

Laboratory Trials:

To examine the interaction between entomopathogenic nematodes and fungi, as well as measure the affects of manure composting on their efficacy and persistence, different rates and combinations of these materials will be infested with both weevil and

waxmoth larvae. Treatments will consist of 1) three rates of a single strain of nematode (Cruiser®) applied alone or in combination, 2) three rates of an entomopathogenic fungus (*B. bassiana*, Mycotech©), 3) three levels of manure compost (low N_2, high N_2, and none), 4) three moisture levels, and 5) three post-treatment dates of larvae inoculation to measure persistence. The manure/nematode/fungus media will be stored inside 30 cm long PVC pipes, so that soil moisture at root depth can be simulated. The pipes will be stored at a constant temperature, but moisture levels will be regulated by the frequency of watering. At appropriate intervals, weevil and waxmoth larvae will be introduced to the media through a small hole drilled in the side of the pipe 20 cm from the top. Larvae will be exposed for four days, then transferred to individual containers to monitor infection and mortality. Soil moisture can also be measured through the hole. Treatments will be replicated five times, over time.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

The black vine weevil (*Otiorhynchus sulcatus*) is a serious pest of red raspberry in the Pacific Northwest. Current methods of root weevil suppression have not been effective, especially efforts targeting the subterranean larvae. Novel insecticides (e.g., azadiractin, etc.) likewise target adult weevils.

The entomopathogenic and microbial agents described here offer an opportunity to develop not only an effective, but also more selective and hopefully more sustainable weevil management program. Both entomopathogenic nematodes and fungi may persist and remain active in the soil for months. These agents also have low mammalian toxicity.

Results will be transferred to raspberry growers directly via growers' meetings, newsletters, and progress reports. These studies will also be published in manuscript form in appropriate scientific journals and will be presented at regional and national scientific meetings.

BUDGET:

	ITEM		COST
01	Salary - 0.25 FTE [1]		6563
07	Benefits (Social Security, etc.: 30% of 01)		1969
		TOTAL:	8532

[1] ¼ Postdoctoral Research Associate

Current Support (expires 3/96)

Title of Project	Total $ Amount	Granting Surce
Trials Of Entomopathogenic Fungi Against Root Weevils In Strawberry	3980	Washington State Strawberry Commission
Biological control agents against the black vine weevil	4080	Washington State Cranberry Commission
Survey of Oregon cranberry bogs for entomopathogenic fungi which suppress the black vine weevil	2000	Oregon Cranberry Growers Association

Project No:

Title: Control of root weevil larvae on red raspberries by field applications of entomogenous(insect-killing) nematodes

Year Initiated: 1996 Current Year Terminating Year 1996

Personnel: Craig MacConnell, Horticulturist, WSU Coop. Ext., Bellingham
Geoff Menzies, Nooksack Watershed IPM Project Coordinator
with cooperation from:
Lynell Tanigoshi, Entomologist, WSU, Vancouver

Justification:

This proposal addresses a high priority research need as identified by the Raspberry Commission Research Committee: 1.,b.: Control of weevil larval stage using entomogenous nematodes.

Growers are currently dependent on an adulticide program for weevil control. Pesticides used for this purpose are often quite effective but can disrupt naturally occurring biological control of spider mites. The larval stage which is currently not targeted allows this pest to overwinter, damage roots, and re-infest the following season as adults. There are no soil applied pesticides currently registered for larval control. Entomogenous nematodes have potential as an environmentally safe method to control this damaging stage of the insect.

There has been some field experimentation in raspberries with this product in Whatcom County in the past but adequate control was not achieved. This was probably due to method of application(applied to soil surface) which resulted in excessive nematode mortality and poor delivery of the control agent to the pest's environment. Success with this product also depends on maintenance of proper soil moisture which allows the nematode to migrate in the soil and locate its' host. The increased use of subsurface drip irrigation systems may enhance the delivery and efficacy of this biological pesticide.

Objectives:

1. Test entomogenous nematodes for efficacy against root weevil larvae in the field.

2. Build capacity within raspperry growers to plan, conduct and evaluate on-the-farm research.

These objectives will be addressed this funding year.

Procedures:

Objective 1: Nematodes used in this experiment will be purchased from Biosys, the leading supplier of formulated nematodes for agricultural pest control. They will be applied either by direct injection into the hills or through subsurface drip irrigation systems. Treatments will be made to replicated plots in two fields in Whatcom County which have a history of high black vine weevil populations. Larval population will be estimated prior to treatment in April, 1996. Efficacy will be determined primarily by post-treatment sampling of weevil larvae. If necessary WSU research in Vancouver can assist with lab analysis to confirm presence of entomogenous nematodes.

Objective 2: Identify cooperators who will play a key role in research site location, experiment design, application of materials and data collection and analysis.

Anticipated Benefits and Information Transfer:

If effective, entomogenous nematodes could provide another option for controlling the major pest of raspberries, black vine weevil. This could supplement the existing adulticide program or possibly replace it in some situations. Nematodes have the advantage of being an environmentally friendly tactic and targeted insects are less likely to develop resistance. In addition, nematodes formulated for biological pest control are exempt from EPA registration requirements.

This project fits nicely with the on-farm research component of the Nooksack Watershed IPM Project. Information would be transferred during the season using field workshops and at grower meetings during the winter. Findings could also be incorporated into extension bulletins and spray guides.

Budget

	1996
Salary(a)	0
Time Slip(b)	1,000
Operations/ materials(c)	150
Travel(d)	200
Equipment(e)	50
Employee Benefits(f)	160
TOTAL	$1,560

a)Oversight by Nooksack IPM Coordinator
b)Field work, post treatment lab analysis
c) Entomogenous nematodes
d) travel to fields
e) sampling materials
f)16% time slip wages

Project No:

Title: Management of spider mites on red raspberries by field augmentation of the predatory mite, Amblyseius fallacis

Year Initiated: 1996 Current Year Terminating Year 1996

Personnel: Craig MacConnell, Horticulturist, WSU Coop. Ext., Bellingham
Geoff Menzies, Nooksack Watershed IPM Project Coordinator
with cooperation from:
Lynell Tanigoshi, Entomologist, WSU, Vancouver

Justification:

This proposal addresses a high priority research need as identified by the Raspberry Commission Research Committee: 2.,b.: Field Release of Predatory Mites.

For the past couple of years, raspberry growers have expressed an interest in field releases of predatory mites as a method to manage spider mites. In some situations, it appears that predatory mites provide economic control of spider mite populations in raspberries, thus eliminating the need for post-harvest chemical miticides. It is very difficult to predict when a mite explosion may occur, and considering the pre-harvest interval on Vendex(7 days), many growers are inclined to apply a protectant spray before harvest even in low mite pressure situations. Augmenting predatory mite populations well before harvest may eliminate the need for protectant sprays and delay or reduce spider mite increases during the harvest period, when it is impractical for growers to apply Vendex.

Field releases of Amblyseius fallacis were made in lower mainland BC during the 1995 season in both raspberries and strawberries. Results are not yet available from these studies. Predatory mites are used on a commercial basis for spider mite control on strawberries in California.

Objectives:

1. Test field releases of the laboratory reared, organophosphate and pyrethroid-resistant predatory mite, A. fallacis for efficacy against spider mites in raspberry fields in Whatcom County.

2. Build capacity within raspberry growers to plan, conduct and evaluate on-the-farm research.

Procedures

Objective 1: Predatory mites purchased from Applied Bionomics, Saanichton, B.C. will be released on replicated plots(1/4 acre each) at two farm sites in Whatcom County in late April or early May, 1996. Populations of spider mites and predatory mites will be evaluated prior to release and at two week intervals throughout the season. Effectiveness will be determined by collecting 20-30 leaflets per plot and counting the mites on them.

Objective 2: Identify cooperators who will play a key role in site location, experiment design, application of materials and data collection and analysis.

Anticipated Benefits and Information Transfer:

At the present time, there is only one miticide that growers commonly use to control spider mites. Without viable alternatives, the likelihood for spider mites to develop resistance to this product is increased. If early season augmentation of the naturally occurring A. fallacis is effective, it may provide growers with an alternative method to control spider mites.

This project fits nicely with the on-farm research component of the Nooksack Watershed IPM Project. Information would be transferred during the season using field workshops and at grower meetings during the winter. If this method is effective, follow up work could evaluate larger scale applications of predatory mites and alternative delivery systems.

Budget

	1996
Salary(a)	0
Time Slip	512
Operations/ materials	200
Travel(b)	200
Equipment(c)	1,000
Employee Benefits(d)	82
TOTAL	$1,994

a) Project oversight by Nooksack IPM Coordinator
b) field visits to collect data
c) Mite brushing machine, mechanical counter
d) 16% of time slip

PROJECT NO.: **New**

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

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

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

Lynell K. Tanigoshi
Associate Entomologist

J. Scott Cameron
Associate Horticulturist and Manager

Washington State University Research & Extension Unit, Vancouver

COOPERATORS:

Chuhe Chen, Stephen F. Klauer, Steven Booth, Research Associates, Vancouver
Craig MacConnell, Chair, Whatcom County WSU Coop. Extension
Arthur L. Antonelli, WSU Coop. Extension State Specialist, Entomolgy, Puyallup
Geoff Menzies, Nooksack Watershed IPM Project
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JUSTIFICATION:

A New Partnership. Concern has been expressed in recent years that WSU raspberry researchers, and especially those stationed at the WSU Research & Extension Unit, Vancouver, have not had sufficient physical presence in the northern industry centered in Whatcom and Skagit counties. While most WSU research projects done outside of northern Washington produce results which are relevant and applicable to that area of the state, there are still regional needs for which it is logical to center projects in the heart of the world's largest raspberry industry. With strong demand for raspberry research across a number of disciplinary lines, it is not possible to hire multiple faculty to meet these needs, and our state lacks small fruit positions in applied research\technology transfer in the form of state extension specialists. We propose a flexible, cost effective partnership which brings federal, state, and industry resources together to cooperatively address research needs while enhancing the role of WSU Cooperative Extension in education and technology transfer.

Location. We propose that a "satellite" office of our research programs be developed in Lynden, WA. This office will be operated from 6-12 months per year, will be physically located on a commercial raspberry farm and will be staffed by a technician\project manager and graduate students using local fields for specific research projects established as priorities by industry. Minimal office and "lab" space

for equipment such as microscopes, computers and other research equipment and supplies will be used as a base of operations as we implement research projects in Skagit and Whatcom counties. Drs. Tanigoshi and Cameron as well as other WSU researchers will travel routinely to this location to assist in establishing experiments and to monitor progress. Students pursuing M.S.\Ph.D. programs will interact directly with industry and Cooperative Extension, will serve as a local resource and will be connected to the Vancouver WSU REU by phone, FAX and email.

Contributions. As industry identifies research priorities in entomology and horticulture, graduate student funding will be secured for these projects through federal, state, and industry sources. This creates a flexible approach to staffing critical short and long term projects with specific expertise, focus and dedication. We will contribute equipment (car, computers, lab equipment), graduate students, and the time of state funded scientists (Tanigoshi, Cameron, Klauer, Chen and others). Industry is being asked to house our personnel and provide funding for timeslip labor, travel for PI's to the northern sites, small equipment, supplies and support for graduate students. We anticipate that industry and federal sources will have to be developed for partial or full support of certain field-based graduate student projects.

Advantages. There are many advantages in this arrangement for industry and WSU. It is a cost effective way to move certain projects north, it allows us to pursue research which we otherwise wouldn't have done without an onsite manager and a local base of operations, and it allows researchers to be actively involved with research projects in northern Washington without an unreasonable commitment of our time. Students will benefit from direct access to the industry through mutual education while providing a stronger and more direct tie to our faculty and programs.

OBJECTIVES: (All objectives to be addressed in 1996)

Initial projects proposed integrate industry priorities in entomology and horticulture.

1. Establish base of operations for locally managed, joint, interdisciplinary (entom\hort) projects under the direction of Drs. Tanigoshi and Cameron.
2. Integrated research in biological and chemical control of spider mites and root weevils in terms of control efficacy and plant productivity.
3. Integrated research in the roles of carbon, water, nitrogen, and temperature and pests in sustainable productivity.
4. Enhance the role of WSU Cooperative Extension in education and technology transfer to the Washington red raspberry industry.

BACKGROUND AND PROCEDURES:

ENTOMOLOGY

BACKGROUND. The root weevil complex, especially black vine weevil, *Otiorhynchus sulcatus*, and the twospotted spider mite (TSSM), *Tetranychus urticae*, continue to be identified as the top two research priorities by the commission. Moreover, since the first reported feeding of the yellow spider mite (YSM), *Eotetranychus carpini borealis*, on raspberry, population levels of these phytophages often exceed those of TSSM. What factors are influencing population increase and cohabitation of YSM with TSSM, pesticide induction, horticultural practices, negative impacts on natural enemies (i.e., pesticide selectivity), or phenomen of competitive displacement? Implementation of our satellite research office/lab in Lynden staffed by a project manager and graduate students/trainees will facilitate continued research on a broader array of on-farm research tactics to manage weevils and spider mites. 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 will accelerate mutual discovery of sensible scientific and biological solutions to contemporary red raspberry pest management problems. The project will broaden and deepen traditional IPM tactics of chemical, biological and host resistance and further explore autocidal, cultural, physical, and mechanical controls where deemed appropriate to obtain effective, long-lasting raspberry pest control. The results of the past two year with two chemicals (i.e., new chemistries) were found to be very effective against root weevils while exhibiting selectivity to an array of non-target insects. One of these compounds also demonstrated excellent acaricidal potential.

PROCEDURES

1. Laboratory and Field testing of Root Weevil Adulticides, Monitoring and Heat-Unit Model. Field trials will be conducted at several sites in Whatcom and Skagit counties and the Vancouver Research & Extension Unit. Materials would include: AC303,630 (Stalker, Pirate), fipronil (Regent), bifenthrin (Brigade), cryolite (Prokil). This research will emphasize the selective use of these broadspectrum, high-efficacy, and low-dose insecticides mainly through timing of application (i.e., degree-days, biofix) to control pre-ovipositing weevils or placement of neurotoxins in traps baited with an attractant before they realize their biotic potential. The latter technique represents preliminary research to **evaluate several field monitoring weevil traps** that will be charged with an attractant and/or toxicant. Several prototype adult weevil monitoring traps and experimental attractants will be evaluated at 2-3 commercial fields known to be infested with root weevils. An adult monitoring trap would also provide the industry with a tool to monitor weevil abundance, population

dynamics, and dispersion patterns central to applying pesticides in ways which selectively kill target organisms while minimizing their undesirable side effects. Multiple sites will be monitored with HOBO temperature data loggers placed within weevil overwintering sites in the soil and root zone. These monitors will be placed on site in early January and bi-weekly soil samples taken to assess larval instar development via head capsule measurements. This information will enable us to **estimate the BVW's lower developmental threshold** needed to initiate a **degree-day model** to predict both overwintering adult and "new" adult emergence and when to best place adult monitoring traps in the field. Both the DD model and monitoring traps will provide us with the information needed to properly time and evaluate different insecticides as **prebloom spray to control preovipositional females.** Postharvest and spring foliage samples should provide appropriate data needed to evaluate this chemical tactic that incorporates timing and placement of application at the weevil's "weak point," or possibly spot treatments.

2. *Biological Control of Spider Mite Complex.* Questions about the population dynamics of the TSSM and YSM and the biological impacts of a widespread and potential abundant phytoseiid predatory mite will be addressed by a Ph.D. student in Entomology, Malika Bounfour. This research is currently funded by the USDA/Small Fruits Research Center. Mrs. Bounfour's work will include coordination and assistance with natural augmentation and conservation of the endemic and selectively resistant phytoseiid mite, *Neoseiulus (=Amblyseius) fallacis.* This predatory mite is the most abundant phytoseiid species associated with TSSM on red raspberry in western Washington. In Oregon, *N. fallacis* sill provide commercially acceptable biocontrol of TSSM on strawberry, hops, peppermint, and corn. We will study its **development biology and feeding preference** on dietaries of both TSSM and YSM. Furthermore, extensive **Potter precision spray tower chemical assays** will be conducted on multiple field populations of *N. fallacis* and both spider mites to registered and experimental pesticides. These data will help generate a **pesticide compatibility table** that will summarize relative population susceptibilities and tolerances of these pesticides and their field impacts on spider mites and their natural enemies. Plant phenology and horticultural parameters will be researched (see below) and associated with TSSM and YSM mite-day accumulations. These data, especially those ascertained for raspberry physiological status and yields will hopefully lead to reasonable economic injury levels for both mite species. These economic levels will help growers decide whether chemical control measures are economically justified; this, when coupled with mite/natural enemy (phytoseiids, *Stethorus punctum, Orius* spp. pirate bus) ratio per leaf.

HORTICULTURE

BACKGROUND. Industry and federal funding for research at Vancouver has developed a very strong and unique program in understanding 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. This study will address these issues in the northern region of the state where the combination of these factors is the most critical from year to year. For example, while tying canes (hoops) can increase yields over topping, there are a significant number of years when this yield increase is probably not fully or partially obtained, presumably due to weather or other internal factors. This issue could be related to prior depletion of carbohydrate status in years in which "additional" fruit is recovered from the top of the plant.

PROCEDURES

Temperature, Phenology, Nutrition and Yield. Paired plots will be established on four farms 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. These units will be useful for a wide range of studies and will be shared among researchers' projects in the future. 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.

Training System Interaction with Location, Temperature and carbohydrate Status. Plots of tied and topped 'Meeker' will be established in Lynden and Vancouver to compare yields of the training systems at two sites. A "new" two wire trellis for rotary harvesters developed in Chile will also be trialed to increase yield and harvest efficiency as it embodies all of the critical components our program has identified in recent years. Yield estimates will be performed on canes monitored for carbohydrate

status, nutritional status and field temperature. The purpose of this experiment is to determine the factors critical in obtaining sustainable yields over time.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

Benefits: These integrated studies will consider a number of factors in concert which will result in answers to long standing questions in our industry. 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 also 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.

BUDGET:

	1995-96 Request
00 Salaries 0.5 FTE Ag Res Tech I (Project Manager)	12,000
01 Wages (Temporary employees - summer)	6,000
03 Supplies and services (field supplies, nutritional analysis)	2,500
04 Travel (Tanigoshi\Cameron)	2,500
05 Equipment (HOBO Temp recording devices, microscope)	4,000
07 Benefits (26% of 00)	3,120
07 Benefits (16% of 01)	960
TOTAL	$ 31,080

IN-KIND INDUSTRY SUPPORT

Office space, access to fields, assistance with plot maintenance and data collection.

MATCHING WSU SUPPORT

State vehicle, equipment (microscopes, computer, FAX, lab equipment), graduate student support, research scientists' time.

OTHER SUPPORT OF PROJECT: As a new project, there is no current support for establishing a WSU satellite office in northern Washington. Research described herein is new and not currently funded.

Project No:

Title: Development of chemotherapy strategies to produce virus free Rubus plants.

Year Initiated 1996 Current Year 1995 Terminating Year 1998

Personnel: Robert R. Martin, USDA-ARS Northwest Center for Small Fruit Research Center, 3420 NW Orchard St., Corvallis, OR 97330; and Elzi Volk, Dept. of Botany and Plant Pathology, Oregon State University, Corvallis, OR.

Justification:

One of the biggest bottlenecks for breeders is the length of time it takes to eradicate virus from Rubus selections before they can be put into yield trials. To date all virus eradication in Rubus is based on thermal therapy and meristem tip culture. This procedure is both labor intensive and very time consuming. If we could increase the throughput of the virus eradication program then the breeders would have more selections to study in the field and hopefully, the time between making a cross and releasing a variety would be shortened. Riboviran has been used successfully to eliminate viruses from a number of crop plants and should be useful in raspberry.

This project will complement the virus elimination program currently in place at Oregon State University. A similar project is being undertaken with strawberry where we have shown that chemotherapy can be used to successfully eliminate viruses.

Objectives:

1. Setup phytotoxicity trials with 5 raspberry genotypes in tissue culture and in growth chambers. The growth chamber studies will include soil drenches and foliar application of the chemical.
2. Setup virus elimination trials with tissue culture plants, and potted plants in growth chambers.
3. Take tissue pieces of various sizes from the plants treated with riboviran. These tissue pieces will be propagated in tissue culture. Root cuttings will also be taken from the potted plants and as shoots emerge from the cuttings they will be removed and rooted in the greenhouse.
4. Test propagated plants for viruses and determine the most efficient

means of producing the virus-free plants.

This funding year we will be addressing objectives 1 and 2.

Procedures:

For the phytotoxicity trials we will use 5 cultivars of raspberry, trying to select cultivars that are as genetically diverse as possible. The purpose of this trial is to get an idea of the range of tolerance raspberry varieties have for riboviran. We suspect there will be variation in tolerance to the chemical by different varieties and need to get an idea of the range. Once we have a range of toxicities then we can set up a number of plants with known viruses to determine how readily various viruses are eliminated. The reason for using tissue culture plants and whole plants is to determine the easiest route to treat the plants. If we can use whole plants and use shoots from root cuttings it might be possible to produce virus-free plants without going through a tissue culture step.

Plants will be virus tested before the treatment and after treatment to assess the efficiency of eradication. Elzi Volk has a range of plants with known virus infections that we will use in this study. We will also be using plants with mixed infections. We would like to develop a treatment that will give 90% or greater virus free plants. Then the breeders could take the material straight to the field even before it is virus tested. As the virus testing is completed they may have to eliminate a few plots. This is only for the breeders field trials. Before material is released to nurseries it will still have to be completely tested to ensure it is virus free.

Anticipated Benefits and Information Transfer

The chief benefit of this research will be a more efficient means of producing virus-free plants. The information will be available to breeders as it becomes available. As soon as we have information on the best means of applying the chemical to eliminate viruses we will work with the breeders to get material in the system.

Budget:

Request for 1996-97	4000
Salaries:	3500
Operations, media	500

This project is also being submitted to the Oregon Raspberry and Blackberry Commission and to CAAR for funding. If we get enough support for the project we hope to have a graduate student do the project. This would give us continuity over the 3 years of the project.

Project No:

Title: Evaluation of raspberry cultivars and advance selections suitability for processing and machine harvest.

Personnel: Chaim Kempler and Hugh Daubeny
Agriculture and Agri-Food Canada, Pacific Agriculture Research Centre
(Agassiz, Vancouver)

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

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

Primary

-Winter hardiness (withstand low temperatures and desiccating winds throughout winter months, and late breaking dormancy.
-Manageable plant habit that is suitable for machine harvesting, with high yields.
-Aphid resistance, which controls the Raspberry Mosaic Virus Complex (RMVC), Resistance breaking biotype will have to be considered in the future.
-Superior fruit qualities for processing that include flavour, size, firmness, ease of harvest, rot resistance
-Large fruit that is easy to remove which is essential for machine harvesting.
-Processing fruit needs to be dark, have high acid and soluble solids content.
-Resistance to pollen infection from Raspberry Bushy Dwarf Virus (RBDF).

Secondary

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

Impacts and benefits: The results of the evaluations will be directly available to the red raspberry industry and will determine which selections are most suitable for processing and machine harvest. The evaluations will help in determine if selections like 86-6-15, 87-5-1, 87-18-7 and others are commercially suitable and can replace Meeker.

Activities

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

Funding: While the total cost of the evaluation and the development of new raspberry cultivars suitable for processing and machine harvest should be about $ 120,000 over three years ($ 40,000 per year) we are asking Red Raspberry Commission share for the three year to be $ 15,000 ($5,000 per year). The Red Raspberry Commission contribution will be matched by Agriculture and Agri-Food Canada Matching Initiative Funding (MII) with $ 15,000.

Resource commitments (for each year between April 1996- March 1999):

Funds require to hire a person for the period of April 1- Nov 30,	$ 18,200
Summer students (2x$7,500)	$ 15,000
Land preparation (fertilizer, field fumigation, etc)	$ 5,000
O&M (drip irrigation, trellis, etc)	$ 6,000
Travel to Meetings	$ 2,350
Total	**$ 46,550**
Collaborative partners contributions:	
Lower Mainland Horticultural Improvement Association	$ 5,000
B.C. Raspberry Growers Association	$10,000
B.C. Raspberry Industry Development Council	$10,000
Washington State Red Raspberry Commission	$ 5,000
Oregon Raspberry & Blackberry Commission	$ 5,000
Matching Initiative Funding (MII) *	$35,000
Total	**$70,000**

* Agri. & Agri-Food Canada will match up to 100% industry contribution.
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