1992
RED RASPBERRY RESEARCH PROPOSALS

1991 PROGRESS REPORTS

to the

WASHINGTON STATE RED RASPBERRY COMMISSION

and

NORTHWEST RED RASPBERRY GROWERS ASSOCIATION

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1991-92

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SUMMARY
BUDGET REQUEST

PROJECT NUMBER	SHORT TITLE	LEAD SCIENTIST	AMOUNT REQUESTED
ON-GOING PROJECTS			
13C-3755-5641	Red Raspberry Breeding	Moore	$23,500
13C-3755-8640	Advanced Testing	Moore	1,500
13C-3755-4640	Machine Harvesting	Moore	1,250
13C-3755-3775	Cold Hardiness	Hummel	4,123
13C-3761-1741	Ground Water Contamination	Bristow	1,460
13C-3761-2763	React. to Ridomil	Bristow	1,800
13C-3543-2857	Overwintering - Mites	Shanks	9,848
13C-3555-2783	Caneburning	Cameron	5,400
13C-3555-5783	Leaf/Fruit Ratio	Cameron	3,600
13C-3555-5956	Micropropagation	Cameron	-0-
13C-3555-4883	Mite Feeding - Physiology	Cameron	2,800
	Trans/Coat Protein/Dwarf Virus	Martin	4,500
		SUB-TOTAL	$59,781
NEW PROJECTS			
	Control Root Weevils	Shanks	4,000
		SUB-TOTAL	$ 4,000
		GRAND TOTAL	$63,781

PROJECT NO.: 13C-3755-5641

TITLE: Red Raspberry Breeding, Genetics and Clone Evaluation

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

JUSTIFICATION:

Red raspberry breeding programs in the Pacific Northwest (PNW) have been very successful, as indicated by the fact that virtually all of the commercial acreage in this region utilizes cultivars developed by these programs. Willamette has been a consistent producer of fruit suitable for processing since its release. Meeker is currently the most widely planted cultivar in the PNW.

New cultivars are needed which are better suited for fresh marketing. In addition, improved resistance to *Phytophthora* root rot and immunity to raspberry aphid (a vector of several viruses) are needed. Research by Agriculture Canada scientists has demonstrated that aphid immunity effectively controls the spread of Raspberry Leafspot Virus, a disease found in many PNW raspberry plantings. With the increase in labor costs and difficulty obtaining labor, suitability to machine harvesting is increasingly important. Finally, cultivars with improved marketable yields and fruit quality are also needed.

OBJECTIVES:

1. Develop 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.

2. Study the inheritance of fruit characteristics critical to fresh marketing (fruit weight, retention strength, firmness, color and soluble solids).

3. Propagate and evaluate red raspberry clones for trueness to type, yield and fruit quality.

PROGRESS:

Twenty five crosses were made in 1991. Schonemann, an aphid resistant, cold hardy, dark colored cultivar, was used extensively as a parent. Crosses were also made between red raspberry and North American red raspberry, purple raspberry (black raspberry x red raspberry hybrid) and derivatives of an Asiatic species. Approximately 3,000 seedlings from crosses made in 1990 were planted in 1991. These seedlings will be evaluated in 1992 and 1993.

Twenty three selections and cultivars were planted in replicated trials for yield and fruit quality evaluations. Selections were also planted in soil infested with root rot at Puyallup to determine the level of susceptibility to disease. Additional plantings of 12 clones were made to provide material for cold hardiness studies and 14 clones to provide fruit for studies on fruit characteristics.

Fifteen selections were made among seedlings planted in 1989. There was severe widespread root rot throughout the seedling planting. The plants appeared healthy fall 1990, but by summer 1991 over 50% were killed. Although many seedlings died prior to evaluation, this provided intense selection pressure for root rot tolerance. The best parents were WSU 991, Schonemann, SHRI 6820/64, and Chilliwack. An additional 6 selections were made from a cross between a Russian accession and WSU 930. Seedlings from this cross were very vigorous and tolerant to root rot. Fruit was medium in size, orange to medium red, soft and began ripening in mid August. Although these selections are not suitable for cultivars, they will be used as parents in 1992.

WSU 942 and WSU 968 in the 1986 and 1987 selection trials were observed in 1991. The performance of WSU 942 in 1991 did not warrant further evaluation. WSU 968 had attractive firm fruit that released easily when ripe. There was interest in this selection at the raspberry field day and it will be propagated for grower trials and further testing.

The 1988 selection trial was harvested for the second time in 1991 (Table 1). Because the planting was young and not well established in 1990, it was not cane burned last year. By 1991, the planting was well established and was cane burned with Goal. The yields and fruit weights were very large. Six of the 13 clones in the planting yielded 10 t/a or more including Meeker and Centennial. The highest yielding clone was WSU 988 with 12.2 t/a. WSU 991, WSU 984, and WSU 983 also had 10 t/a or more in 1991. All 4 selections will be evaluated in 1992.

WSU 991 is a promising yellow fruited selection with high yields. It had the largest fruit in both 1990 and 1991 and was among the firmest both years. Plants were distributed to commercial growers for grower evaluation in 1991. Plants will be distributed to commercial propagators and decisions regarding naming and release made in 1993 after grower evaluation.

The 1989 selection trial was harvested for the first time in 1991 (Table 2). It was not cane burned in 1991. It is in an area were there is root rot and was treated with Ridomil, but susceptible clones were showing root rot symptoms. Meeker was the highest yielding clone. WSU 994, WSU 1004, and WSU 1007 had over 6.5 t/a. WSU 994 had very large fruit. This selection trial will be harvested again in 1992.

Six fall fruiting cultivars planted in 1990 were evaluated in 1991 (Table 3). Summit was the earliest maturing, but fruit size was small. Autumn Bliss had the best fruit quality.

Virus-free propagation material was maintained at Puyallup. Plants of Pacific Northwest cultivars and advanced selections were distributed to certified plant propagators.

PROPOSED RESEARCH:

Crosses in 1992 will again emphasize aphid resistance and root rot resistance. Hybrids with the Russian material will be used extensively. Selections made in 1991 will be planted along with standard cultivars in replicated yield trials and root rot evaluation plantings at Puyallup. Selections will be made among seedlings planted in 1990. Selections in the 1989 and 1990 selection trials will be harvested for yield, fruit weight, firmness, preharvest fruit rot, and season of harvest. The most promising selections in the 1988 selection trial will be evaluated again in 1992 and decisions made for propagation for further testing.

Plants from nuclear stock will be distributed to Washington certified plant propagators. A sample of plants will be fruited out at Puyallup to test for freedom from crumbliness and trueness to type.

TERMINAL DATE OF BASE PROJECT: June 1994.

DURATION OF THIS PROPOSAL: Second of three years.

BUDGET:

	1991-92	1992-93
00 Salary	$ 8,554 (.4 FTE)	$10,283 (.45 FTE)
01 Wages	5,000	5,000
03 Supplies and Services	4,172	4,124
04 Travel	300	300
07 Benefits	2,474	3,793
Total	$20,500 (requested) $18,200 (received)	$23,500

Table 1. 1990-91 harvest of 1988 planted raspberries at Puyallup, WA.

CLONE	yield (t/a) 1991	yield (t/a) 1990	yield (t/a) total	fruit rot (%)	fruit weight (g)	fruit firmness (g)	Harvest season 5% harvest	Harvest season 50% harvest	Harvest season 95% harvest	length of season
WSU 988	12.2 a	5.5	17.6	1.4 a - c	3.7 b c	153 b c	7/3 d e	7/13 e f	7/25 e f	22 b - f
WSU 991	10.8 a - c	5.6	16.4	1.5 a - c	5.0 a	206 a	7/2 e f	7/12 f g	7/23 f	21 e f
WSU 984	11.4 a b	4.9	16.4	1.7 a b	4.7 a	210 a	7/4 d	7/15 c - e	7/28 c d	24 b c
CENTENNIAL	11.3 a b	4.1	15.4	1.1 a - c	4.1 b	176 a b	7/4 d	7/14 c - e	7/28 c d	24 b c
WSU 983	10.0 a - d	5.3	15.3	1.1 a - c	3.4 c d	149 b c	7/3 d e	7/11 g	7/23 f	20 f
MEEKER	10.3 a - d	5.1	15.3	0.6 b c	3.1 d e	152 b c	7/9 a	7/18 a	7/31 a - c	22 c - f
WSU 985	9.0 b - d	5.9	14.9	1.9 a	2.8 e	131 c	6/29 g	7/8 h	7/23 f	24 b - d
WSU 979	9.2 a - d	5.3	14.5	1.1 a - c	3.3 c d	144 b c	7/6 c	7/15 c d	7/27 d e	21 d - f
CHILCOTIN	9.7 a - d	4.2	14.0	0.7 a - c	3.7 b c	146 b c	7/2 e f	7/14 c - e	7/31 a b	29 a
BC 80-28-50	8.4 b - d	5.5	13.9	0.4 c	3.0 d e	140 b c	7/8 a b	7/17 a b	8/2 a	25 b
WSU 982	7.8 c d	5.3	13.0	1.5 a - c	3.6 c	198 a	7/3 d e	7/13 d - f	7/26 d e	23 b - e
WSU 989	7.9 c d	3.6	11.5	0.7 a - c	2.9 d e	129 c	7/7 b c	7/15 b c	7/29 b - d	21 d - f
WILLAMETTE	7.2 d	3.2	10.5	0.9 a - c	2.9 d e	130 c	7/1 f	7/11 g	7/25 e f	23 b - e
AVERAGE	9.6	4.9	14.5	1.1	3.6	159	7/4	7/13	7/27	23

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 2. 1991 harvest of 1989 planted raspberries, Puyallup, WA

CLONE	Yield (t/a)	Fruit rot (%)	Fruit weight (g)	Fruit firmness (g)	Harvest season: 5% Harvest	Harvest season: 50% Harvest	Harvest season: 95% Harvest	length of season
MEEKER	7.8 a	0.7	2.5 f - i	124 d - h	7/6 b - d	7/16 c d	7/29 b - d	24 a - c
WSU 994	7.3 a b	1.8	4.0 a	157 b - d	7/3 d - h	7/13 g - k	7/27 d - f	24 a b
WSU 1004	7.2 a - c	0.7	2.5 g - j	87 i j	7/8 a b	7/17 b c	7/28 c - f	20 d - f
WSU 1007	6.7 a - d	1.6	2.7 d - g	169 b	7/7 a - c	7/17 b c	7/31 b c	24 a - c
WSU 892	6.2 a - e	1.1	2.7 c - g	148 b - e	7/3 e - h	7/13 g - k	7/23 g - i	21 b - f
WSU 1006	6.1 a - f	1.3	2.9 c - f	169 b	7/3 e - h	7/16 c - e	7/28 c - f	25 a
WSU 933	5.9 a - f	1.2	2.8 c - g	120 d - i	7/7 a - c	7/19 b	7/31 b	24 a
BC 80-28-50	5.7 a - f	1.7	2.2 i j	102 f - j	7/3 d - h	7/15 c - f	7/29 b - d	26 a
CENTENNIAL	5.7 a - f	0.9	3.0 c - e	122 d - i	7/3 d - h	7/16 c - e	7/28 b - e	25 a
WILLAMETTE	5.5 a - g	2.5	2.5 g - j	118 e - i	7/2 g h	7/11 k l	7/22 h i	21 b - f
WSU 1009	5.5 a - g	0.5	3.5 b	165 b c	7/2 g h	7/12 i - l	7/21 i	20 e f
SKEENA	5.4 a - h	1.6	2.4 g - j	134 b - f	7/1 g h	7/13 g - k	7/25 e - h	24 a - c
WSU 997	5.3 a - h	2.5	2.4 g - j	80 j	7/1 h	7/11 k l	7/23 g - i	23 a - e
WSU 1001	5.1 b - h	0.4	2.1 j	103 f - j	7/3 d - h	7/10 l	7/22 h i	19 f
CHILCOTIN	5.1 b - h	1.6	2.6 e - h	96 g - j	7/2 f - h	7/11 j - l	7/23 g - i	21 b - f
WSU 1010	5.0 b - h	1.4	2.2 i j	118 e - i	7/1 g h	7/13 h - k	7/24 f - i	23 a - d
WSU 1003	4.6 c - i	1.1	2.4 g - j	103 f - j	7/5 b - e	7/15 d - g	7/26 e - g	20 c - f
CHILLIWACK	4.5 d - i	0.8	2.4 g - j	146 b - e	7/4 d - g	7/13 h - k	7/24 g - i	20 e f
WSU 995	4.5 d - i	1.0	2.2 i j	129 c - g	7/2 g h	7/13 f - j	7/26 d - g	25 a
WSU 1005	3.9 e - i	1.2	2.9 c - e	147 b - e	7/2 f - h	7/16 c - e	7/28 b - e	26 a
COMOX	3.9	1.0	2.6	153	7/3	7/13	7/25	22
WSU 908	3.4 f - i	0.9	3.1 b c	208 a	7/9 a	7/23 a	8/3 a	25 a
WSU 996	3.0 g - i	7.0	3.1 c d	155 b - e	7/1 g h	7/15 d - h	7/26 d - g	25 a
WSU 1011	2.8 h i	1.3	2.2 i j	88 h - j	7/2 g h	7/14 e - i	7/26 d - g	24 a
WSU 1008	2.1 i	3.1	2.2 h - j	145 b - e	7/5 c - f	7/17 c d	7/28 c - f	23 a - e
AVERAGE	6.1	1.6	2.6	131	7/3	7/14	7/26	23

Means are averages of three 3 hill plots, except Comox which was present in two plots and was omitted from the statistical analysis.
Means within columns followed by the same letter are not significantly different using Duncan's Multiple Range Test, P = 0.05.

Table 3. 1991 harvest of 1990 planted fall-bearing raspberries.

Clone	Yield (t/a)	Fruit rot (%)	Fruit * weight (g)	Fruit * firmness (g)	Harvest season 5% harvest	50% harvest	95% harvest	length of harvest
SUMMIT	2.77 a	2.0 a	2.9 b	171 a	8/8 d	8/26 d	9/23 b	46 a
REDWING	2.54 a	0.1 b	3.3	136	8/29 a - c	9/20 a b	9/29 a	31 b c
AUTUMN BLISS	2.44 a	0.8 a b	4.3 a	145 a	8/19 c d	9/11 c	9/27 a	39 a b
RUBY	2.10 a b	0.0 b	4.9 a	206 a	8/25 b c	9/18 b	9/29 a	35 a b
HERITAGE	1.49 b	0.0 b	-	-	9/10 a	9/22 a	9/30 a	20 c
AMITY	0.79 c	0.2 b	3.4	290	9/1 a b	9/19 a b	9/30 a	29 b c
Average	2.02	0.5	3.7	190	8/25	9/14	9/28	33

Means are averages of three 4 hill plots
Means within columns followed by the same letter are not significantly different using Duncan's Multiple Range Test, P=0.05

* Fruit weight and firmness determined at August 28, 1991 harvest. Amity, Heritage, and Redwing did not have all three plots harvested on that date and were omitted from the analysis.

PROJECT NO.: 13C-3755-8640

TITLE: Advanced Testing of Washington State University Raspberry Selections

PERSONNEL: Patrick P. Moore, Assist. Horticulturist, WSU REC Puyallup
J. Scott Cameron, Assist. Horticulturist, WSU Vancouver

JUSTIFICATION:

Developing a new raspberry cultivar is a long-term process. Promising selections must be 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 replicated plantings at WSU Puyallup, WSU Mt. Vernon, and WSU Vancouver of advanced selections from the Washington State University and other regional raspberry breeding programs.

2. To measure yield, fruit quality, and susceptibility to pests in these selections as part of the ongoing cultivar development process.

3. To measure genotype by environment interactions in these selections for traits under improvement.

PROGRESS:

Plots established in 1988 at Vancouver, Mt Vernon and Puyallup were harvested for the second time in 1991 (Table 1). To reduce costs, only WSU 892, WSU 908 and Meeker were harvested. WSU 781 and WSU 805 had poor vigor in at least one location and were not harvested. The highest yielding cultivar was Meeker, but WSU 908's yield was not statistically different. There were significant clone x location statistical effects for fruit rot, and for the time of harvest. Clone x location effects result from clones responding differently to different environments. For yield, there were significant clone effects (the different

clones had different yields) and there were location effects (the yield was the highest at Puyallup and lowest at Vancouver), but there were no clone x location effects because all clones responded to differences in location in the same way. WSU 908 was consistently the latest to start producing fruit and the latest to finish at all locations.

As a result of these harvests, WSU 908 will be tested further in grower trials. The yield and fruit size of WSU 908 was good at all three locations. The notable feature about WSU 908 is its harvest season. It was 7 days later than Meeker in midpoint of harvest. The size of the fruit did not decrease over most of the season. WSU 908 may have a niche as a late season fresh market fruit that would overlap with fall fruiting raspberry cultivars. WSU 892 will be discarded. It has been used extensively as a parent.

WSU 991 was distributed to four growers in Washington for grower trial. Plants will be distributed to commercial propagators and decisions regarding naming and release made in 1993 after grower evaluation.

WSU 968 was observed in the 1987 selection trial. It had attractive firm fruit that released easily when ripe. There was interest in this selection at the raspberry field day and it will be propagated for grower trials and further testing.

WSU 988, WSU 984 and WSU 983 from the 1988 selection trial will be observed in 1992 and decisions regarding further testing made in 1992.

PROPOSED RESEARCH:

In 1992, WSU 908 and WSU 968 will be propagated from field material and distributed to commercial growers. WSU 991 will be distributed to commercial plant propagators.

New plantings including WSU 988, WSU 984 and WSU 983 and other promising selections will be established at WSU Puyallup and WSU Vancouver.

TERMINAL DATE OF BASE PROJECT: June 1994.

DURATION OF THIS PROPOSAL:

First of three years.

BUDGET:

Budget is for propagation of plants and establishment and maintenance of plots at WSU Vancouver.

		1991-92	1992-93
01	Wages	$2,700	
03	Goods and Services	315	$1,500
07	Benefits	135	
	Total	$3,150 (requested) $1,590 (received)	$1,500

Table 1. 1991 harvest summary of 1988 planted raspberries.

	Yield (t/a)	Fruit rot * (%)	Fruit weight (g)	5% * Harvest	50% * Harvest	95% Harvest	Length of * Harvest
ALL LOCATIONS							
MEEKER	9.9 a	1.6	3.5 a	7/7	7/17	7/29 b	23
WSU 892	6.7 b	3.9	3.6 a	7/4	7/14	7/26 c	22
WSU 908	8.2 ab	3.1	3.8 a	7/10	7/24	8/7 a	28
Average	8.3	2.9	3.6	7/7	7/18	7/31	24
Mt Vernon							
MEEKER	9.8 a	3.7 a	3.3 c	7/7 b	7/18 b	7/31 b	24 b
WSU 892	7.2 a	5.6 a	3.6 b	7/5 b	7/16 b	7/30 b	24 b
WSU 908	7.9 a	7.9 a	4.2 a	7/12 a	7/30 a	8/11 a	30 a
Average	8.3	5.7	3.7	7/8	7/21	8/3	26
Puyallup							
MEEKER	12.1 a	0.7 a	3.4 a	7/8 b	7/17 b	7/30 ab	22 a
WSU 892	7.2 a	1.3 a	3.5 a	7/4 c	7/13 b	7/25 b	21 a
WSU 908	9.3 a	1.0 a	3.6 a	7/11 a	7/22 a	8/4 a	25 a
Average	9.5	1.0	3.5	7/7	7/17	7/30	23
Vancouver							
MEEKER	7.9 a	0.5 b	3.7 a	7/6 b	7/17 b	7/28 b	22 b
WSU 892	5.8 a	4.9 a	3.7 a	7/4 b	7/13 c	7/25 b	21 b
WSU 908	7.4 a	0.5 b	3.7 a	7/8 a	7/22 a	8/7 a	30 a
Average	7.0	1.9	3.7	7/6	7/17	7/30	24

Means are averages of three 3 hill plots at each location.
Means within columns for each site followed by the same letter are not significantly different using Duncan's Multiple Range Test, P=0.05.

* Significant clone x location effect for these measurements.

PROJECT NO.: 13C-3755-4640

TITLE: Machine Harvesting Trial

PERSONNEL: Patrick P. Moore, Assistant Horticulturist, Washington State University Puyallup Research and Extension Center
Craig MacConnell, Cooperative Extension, Whatcom County, Bellingham, WA

COOPERATOR: Marty Maberry, Maberry Packing Inc., Lynden, WA

JUSTIFICATION:

An increasing proportion of the red raspberry crop is machine harvested. However, in breeding programs in the Pacific Northwest, selection evaluation is based primarily on hand harvested data. The yield of selections under machine harvesting conditions may differ from the yield when a selection is hand harvested. Two examples are WSU 608 and Centennial. WSU 608 had much greater yields than Willamette when it was hand harvested, but equal or lower yields when machine harvested. The growth habit of this selection resulted in low recovery of the fruit when machine harvested. When Centennial was machine harvested, green fruit and laterals were harvested with the ripe fruit because the fruit did not release from the receptacle easily. In grower trials, selections are tested by growers who hand harvest and by growers who machine harvest. The performance of a selection is compared with cultivars which the grower happens to be growing. Currently, there is no testing where the performance of recent releases and advanced selections are systematically compared under machine harvesting conditions. The performance of recent Pacific Northwest releases and advanced selections under machine harvesting conditions needs to be determined.

OBJECTIVES:

To determine the suitability of new and potential new cultivars to machine harvesting.

PROGRESS:

Plants of Willamette, Meeker, Chilliwack, Comox, Skeena, WSU 892, and Tulameen were planted in replicated plots by Maberry Packing Inc., Lynden, WA, in 1989. Each plot was one post-length long with a space left between plots to clean out the machine. Some plots had several plants which did not

survive. The plots were cut down and allowed to resprout in 1990. BC 83-16-50 was added to the study and planted in missing plots in 1990. Because of lack of funding, no data were collected in 1991.

PROPOSED RESEARCH:

Machine harvested yield:

Each plot will be machine harvested and the machine cleaned out. The total weight of fruit for each plot recorded.

Estimation of potential yield:

The number of canes per hill will be counted prior to harvest. The weight of a 25 fruit sample for each plot will be determined periodically through the season. After the end of the harvest season, one cane per hill will be selected and the number of fruiting sites counted. The potential yield will be estimated from the number of canes per hill, fruiting sites per cane, and average fruit size.

Calculation of harvesting efficiency:

Harvesting efficiency will be calculated from the actual harvested yield and the estimated yield potential.

TERMINAL DATE OF BASE PROJECT:

Fourth year of four. Updated proposals may be written after the fourth year.

BUDGET:

	1989-90	1990-92	1992-93
01 Wages	$ 0	$ 0	$ 450
03 Goods and Services	140	0	600
04 Travel	60	0	164
07 Benefits	0	0	36
Total	$200	$ 0	$1,250

PROJECT NO.: 13C-3755-3775

TITLE: Cold Hardiness of Red Raspberry

PERSONNEL: Rita L. Hummel, Associate Horticulturist and Patrick P. Moore, Assistant Horticulturist, Washington State University Puyallup Research and Extension Center

JUSTIFICATION:

Crop loss due to cold damage is a recurring problem for Washington red raspberry growers. According to the 1986-1987 edition of Washington Agricultural Statistics, the extreme cold during the winter of 1985-1986 and spring frosts caused an average decrease in yield of 1,050 pounds per acre from 1985. The freeze damaged 1986 red raspberry crop was the lowest in average production since 1956. Following the 1987-1988 and 1988-1989 winters, injury attributed to cold was again detected in Washington red raspberry plantings.

The results of this proposed research would provide information on the seasonal change in red raspberry cold hardiness, identify existing red raspberry cultivars and numbered selections adapted to Washington conditions, identify appropriately cold hardy parents for use in the breeding program, and determine the effect of fall fruiting on cold hardiness.

OBJECTIVES:

1. To measure the seasonal change in cold hardiness of buds and stems of field-grown Rubus genotypes of potential importance to the breeding program.

2. To determine the effect of fall fruiting on the development of cold hardiness in canes of 'Willamette' red raspberry.

PROGRESS (1990-1991 Winter):

Cold hardiness of stems and buds of 6 named cultivars ('Algonquin', 'Chilcotin', 'Chilliwack', 'Meeker', 'Schoneman, and 'Willamette') and 8 numbered selections (WSU892, WSU979, WSU982, WSU983, WSU984, WSU985, WSU988, WSU989) was tested on November 15, 1990, January 23 and March 13, 1991. Cold hardiness of two-bud cane sections prepared from 3 plants of each genotype growing in the field at Farm 5 near Puyallup, Washington, was determined in controlled laboratory freezing tests following previously described procedures (Hummel and Moore, 1990, Proc. W. Wash. Hort. Assoc. 80:110-112). Samples were tested at 2 C intervals and tissue injury was determined by the visual browning method. A Tk50, defined as the temperature at which 50% freeze damage occurred, was calculated for the buds and stem of each cane section from the visual browning data.

Results of the November 15, 1990 and January, 23 1991 freezing tests are shown in Tables 1 and 2, respectively. Results of the March 13 freeze test will not be reported because of the difficulties encountered in differentiating between visual browning caused by freeze damage and visual browning caused by invasion of saprophytic fungi in buds that were growing prior to the freeze test. A repeat of the March freeze test is planned in March 1992. Consistent with previous observations, red raspberry buds were freeze damaged at warmer temperatures than the stems. 'Schoneman' a cultivar included in the freeze tests for the first time cold acclimated early in the fall (Table 1), was very hardy in midwinter (Table 2), and seemed to deacclimate slowly in spring (March 13 freeze test, data not shown). This is an indication that 'Schoneman' may be a good source of season-long cold tolerance for use in the breeding program.

WSU892 was one of the hardier cultivars on all 3 freezing test dates during the 1989-1990 winter (Moore and Hummel, 1991, Proc. W. Wash. Hort. Assoc., 81:168-171). Results of the November 1990 (Table 1) and January 1991 (Table 2) freezing tests indicate WSU 892 was again one of the hardier cultivars. This is an indication that WSU892 may have promise as a cold hardy selection. WSU984, a large-fruited, high-yielding selection, also was among the more cold hardy cultivars in the fall and winter freezing tests (Tables 1 and 2).

In February 1990, a preliminary experiment was conducted to determine the potential usefulness of differential thermal analysis (DTA) as a method of quickly measuring the cold hardiness of red raspberry. Results of this preliminary DTA experiment showed exotherms (an indication that water is freezing) were produced in red raspberry buds at temperatures below the free water exotherms. However, the relationship of those exotherms to tissues within the bud and to the actual killing point of the bud was not clear. For example, an exotherm was detected in the 'Chilcotin' bud at about -27°C but results of the visual browning test indicated -22°C was the temperature causing 50% damage and that all the buds were dead by -24°C. The -27°C exotherm was most likely related to freezing of supercooled leaf primordia (which have been shown to be one of the most cold hardy tissues in the red raspberry bud) and not to the functional viability of the bud. Because of the complexity of the bud and the freeze susceptibility of the vascular tissue at its base, it seems unlikely that DTA will be useful for quickly determining the freeze tolerance of red raspberry buds.

Observations made in growers fields following recent freezing events have given an indication that the age of the planting may influence red raspberry cold hardiness. During the 1990-1991 winter, an experiment was conducted to determine whether or not we could detect a plant age effect in laboratory freezing tests. Stem and bud cold hardiness of 'Willamette', and 'Chilcotin' plantings established in 1988, 1989 and 1990 at Farm 5 near Puyallup were determined in laboratory freeze tests as described above. Results of the November 15, 1990 freezing test indicated

the year of planting had no significant affect on cold hardiness of buds and stems of 'Chilcotin' and 'Willamette' (data not shown). However, in the January 23, 1991 freeze test, buds and stems of the 1990 'Willamette' planting were significantly hardier than the 1988 planting. Stem and bud cold hardiness of the 1989 'Willamette' planting fell in between the 1988 and the 1990 plantings and was not significantly different from either one. January 23, 1991, results for 'Chilcotin' stems were not significant. The January 'Chilcotin' bud results indicated the 1989 planting was hardier than the 1988 planting while the 1990 planting did not differ significantly from either the 1989 or the 1988 plantings. Results of this experiment were not conclusive for cultivar or freezing test date. We plan to repeat of this experiment the next time canes from different age plantings of one cultivar are available.

PROPOSED RESEARCH (1991-1992 Winter):

The seasonal cold hardiness pattern in buds and stems of additional red raspberry cultivars and selections important in the breeding program will be measured during the 1991-1992 winter.

The tendency of some red raspberry cultivars to produce fruit in the fall may influence their winter survival. Cold acclimation, ultimate midwinter hardiness and deacclimation of buds and stems of 'Willamette' canes that bore fruit during the fall of 1991 will be compared to nonfruiting 'Willamette' canes. If the results of these laboratory freezing tests indicate fall fruiting has a detrimental effect on cold hardiness, future research will be proposed to evaluate the effect of cultural practices on fall fruiting and cold hardiness.

TERMINAL DATE OF BASE PROJECTS: June 30, 1993 and June 30, 1994

DURATION OF THIS PROJECT: Cold hardiness evaluation of red raspberry genotypes with potential importance to the breeding program is an ongoing project. Determination of the influence of fall fruiting on winter hardiness is a one year project with the possibility of renewal depending upon the results obtained during the 1991-1992 winter.

BUDGET:

	Current 1991	Proposed 1992
00 Salaries	$2,930	$3,165
03 Supplies and Services	50	100
07 Benefits	762	858
TOTAL	$3,565	$4,123

Table 1. Cold hardiness of red raspberry cultivars collected from the field November 15, 1990.

Cultivar	Bud Tk_{50}[z] °F	(°C)		Cultivar	Stem Tk_{50} °F	(°C)	
WSU989	7.3	(-13.7)	A[y]	WSU989	5.0	(-15.0)	A
MEEKER	4.0	(-15.6)	AB	MEEKER	2.5	(-16.4)	AB
WILLAMETTE	3.2	(-16.0)	ABC	WILLAMETTE	2.5	(-16.4)	AB
WSU988	2.5	(-16.4)	BC	WSU988	1.0	(-17.2)	ABC
WSU979	1.9	(-16.7)	BCD	WSU985	1.0	(-17.2)	ABC
WSU985	1.8	(-16.8)	BCD	WSU979	0.0	(-17.8)	BCD
CHILLIWACK	0.3	(-17.6)	BCDE	WSU892	-0.4	(-18.0)	BCD
WSU892	0.3	(-17.6)	BCDE	CHILLIWACK	-0.6	(-18.1)	BCD
CHILCOTIN	0.1	(-17.7)	BCDE	CHILCOTIN	-0.8	(-18.2)	BCD
WSU984	-0.8	(-18.2)	CDE	WSU984	-2.7	(-19.3)	CD
SCHONEMAN	-1.8	(-18.8)	DE	ALGONQUIN	-3.5	(-19.7)	CD
ALGONQUIN	-2.0	(-18.9)	DE	SCHONEMAN	-3.5	(-19.7)	CD
WSU983	-2.4	(-19.1)	DE	WSU983	-3.5	(-19.7)	CD
WSU982	-3.1	(-19.5)	E	WSU982	-4.0	(-20.0)	D
$HSD_{0.05}$	4.3	2.4		$HSD_{0.05}$	4.5	2.5	

[z] Tk_{50} = Temperature at which 50% damage occurred.

[y] Means followed by the same letter are not significantly different at the 5% level using Tukey's Studentized Range (HSD) test.

Table 2. Cold hardiness of red raspberry cultivars collected from the field January 23, 1991.

Cultivar	Bud Tk_{50}[z] °F	(°C)		Cultivar	Stem Tk_{50} °F	(°C)	
WILLAMETTE	- 3.8	(-19.9)	A[y]	WILLAMETTE	- 4.4	(-20.2)	A
WSU989	- 4.5	(-20.3)	AB	WSU989	- 5.1	(-20.6)	AB
MEEKER	- 9.6	(-23.1)	ABC	CHILLIWACK	- 9.9	(-23.3)	ABC
CHILLIWACK	- 9.8	(-23.2)	ABCD	MEEKER	-10.5	(-23.6)	ABC
WSU979	-11.2	(-24.0)	BCD	WSU979	-11.2	(-24.0)	BCD
CHILCOTIN	-11.9	(-24.4)	CD	CHILCOTIN	-12.6	(-24.8)	CDE
ALGONQUIN	-12.1	(-24.5)	CD	ALGONQUIN	-12.6	(-24.8)	CDE
WSU988	-12.1	(-24.5)	CD	WSU983	-13.1	(-25.1)	CDE
WSU983	-12.5	(-24.7)	CD	WSU988	-13.7	(-25.4)	CDE
WSU985	-12.5	(-24.7)	CD	WSU985	-15.0	(-26.1)	CDE
WSU984	-12.8	(-24.9)	CD	WSU984	-15.5	(-26.4)	CDE
WSU892	-13.5	(-25.3)	CD	WSU982	-17.1	(-27.3)	DE
WSU982	-13.7	(-25.4)	CD	WSU892	-18.4	(-28.0)	E[x]
SCHONEMAN	-16.6	(-27.0)	D	SCHONEMAN	-18.4	(-28.0)	E[x]
$HSD_{0.05}$	6.8	3.8		$HSD_{0.05}$	6.5	3.6	

[z] Tk_{50} = Temperature at which 50% damage occurred.

[y] Means followed by the same letter are not significantly different at the 5% level using Tukey's Studentized Range (HSD) test.

[x] The lowest freeze-test temperature in this experiment was -28.0°C.

PROJECT NO.: 13C-3761-1741

TITLE: Potential for Ground Water Contamination from Soil-Applied Pesticides in Red Raspberries

PERSONNEL: Peter R. Bristow, Associate Plant Pathologist
Craig G. Cogger, Associate Soil Scientist
John D. Stark, Assistant Entomologist
WSU Puyallup Research and Extension Center

JUSTIFICATION:

In western Washington, the culture of high-value perennial crops such as red raspberries and strawberries poses special risks of ground water contamination by pesticides for the following reasons.

1. Heavy reliance is placed on the use of insecticides, herbicides, and fungicides, and pesticide use often extends continuously for many years on the same field.

2. Some of the pesticides used on red raspberries have the potential to move through soil, and simazine is on the EPA priority list of potential ground water pesticide contaminants.

3. Soils recommended for red raspberries are well drained and often coarse textured, both of which increase the risk of pesticide movement.

4. Red raspberries are grown on alluvial soils where the ground water aquifer often lies within several feet of the surface. The EPA has designated such agricultural lands as "at risk" with regard to ground water contamination.

To reduce the risk of ground water contamination, pesticides and the land to which they are applied need to be properly managed. To better protect ground water, it is essential to evaluate the potential for pesticide transport through soil to ground water under typical soil and cropping conditions.

OBJECTIVE:

To determine the presence and concentration of the three test pesticides and breakdown metabolites in ground water beneath red raspberries treated with the pesticides.

PROGRESS:

As was planned, water samples at the two test sites were only high enough to obtain ground water samples from the shallow monitoring wells (1-2 m deep) during the rainiest winter months. The water tables never fell below any of the deep monitoring wells (3-4 m deep); hence, water samples were obtained from all deep wells every month. Concentrations of residues found in samples from deep wells were also less than in those from shallow wells.

Metalaxyl: Metalaxyl was detected (at concentrations very near the minimum level of detection) on rare occasion from shallow wells and only once from a deep well at one site (Figure 1). At the second site, metalaxyl was never detected (Figure 5).

Metalaxyl acid: Metalaxyl acid, the primary breakdown product of metalaxyl, was not consistently detected in groundwater from either shallow or deep wells until the second or third winter after the first application of metalaxyl was made (Figures 2 and 6). Concentrations of metalaxyl acid rose until application of metalaxyl was discontinued, and then they began to decline.

Carbofuran: Carbofuran was detected in groundwater samples mainly during the first two years of the study (1986 and 1987), and mostly from shallow wells (Figures 3 and 7). The disappearance in later years, even though carbofuran continued to be applied, most likely represented enhanced biological degradation in the topsoil. Two breakdown products of carbofuran were never detected in groundwater samples from either shallow or deep wells.

Simazine: Concentrations of simazine have continued to decline since the first application in late 1986 even though yearly applications have continued (Figures 4 and 8). At one site (Figure 8), residues have been mostly in water samples from deep wells. The mechanism of movement in soils at this site could be quite different than that at the first site.

PROPOSED RESEARCH:

The final soil and groundwater samples were taken in 1991 and all the groundwater samples have been analyzed. Because residues of metalaxyl acid and, occasionally, simazine are still present in groundwater samples, we propose to continue monitoring groundwater at one site annually (not monthly). We want to find out if residue concentrations continue to decline and how long the residues persist in the samples drawn from both shallow and deep wells.

Analyses of groundwater samples collected monthly have been completed. We have a backlog of soil samples to be analyzed. Soil samples taken a different depths were collected monthly and are being analyzed for the three test pesticides (Table 1). Funds from other sources have been committed to cover the salary of the WSU Research Technician who does this work. This proposal requests funds to help pay for expendable supplies (extraction columns and various solvents, primarily) to complete this final phase of the five-year project.

One-half of the costs are included in this proposal. An identical proposal is being submitted to the Washington Strawberry Commission as strawberry was the other test crop used in this study.

TERMINATION DATE OF THE BASE PROJECT:

Project No. 0741, February 28, 1994

PROJECT DURATION: 1 year

BUDGET:

	1991-92 Last year	1992-93 Proposed
03 Goods and Services	$1,650.00*	
Water analysis		$ 360.00
Soil analysis		1,100.00
Total	$1,650.00	$1,460.00

* All for groundwater analysis.

APPENDIX

Table 1. Test pesticide and breakdown products analyzed for in groundwater samples.

Type	Parent compound	Breakdown product
Fungicide	Metalaxyl (Ridomil)[z]	metalaxyl acid
Insecticide	Carbofuran (Furadan)	3-hydroxycarbofuran 3-ketocarbofuran
Herbicide	Simazine (Princep)	

[z] Common name (trade name)

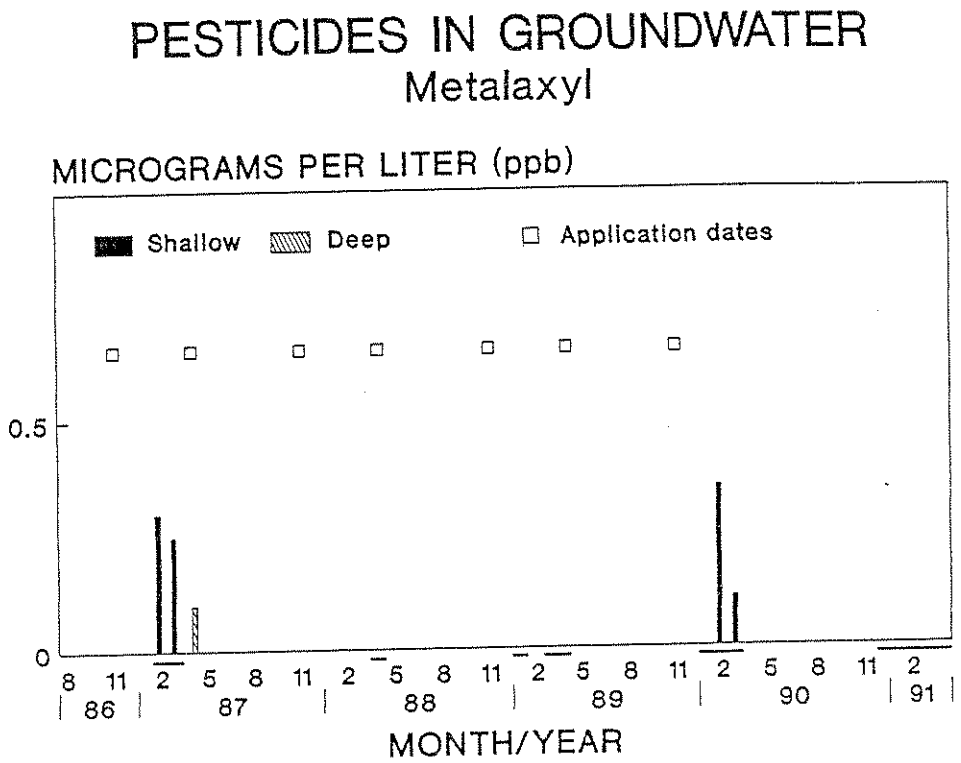
Table 2. Solubility of test pesticides in water.

Pesticide	Solubility, ppm[z]
Metalaxyl	7,100
Carbofuran	300
Simazine	5

[z] ppm = parts per million (μg/ml or mg/L).

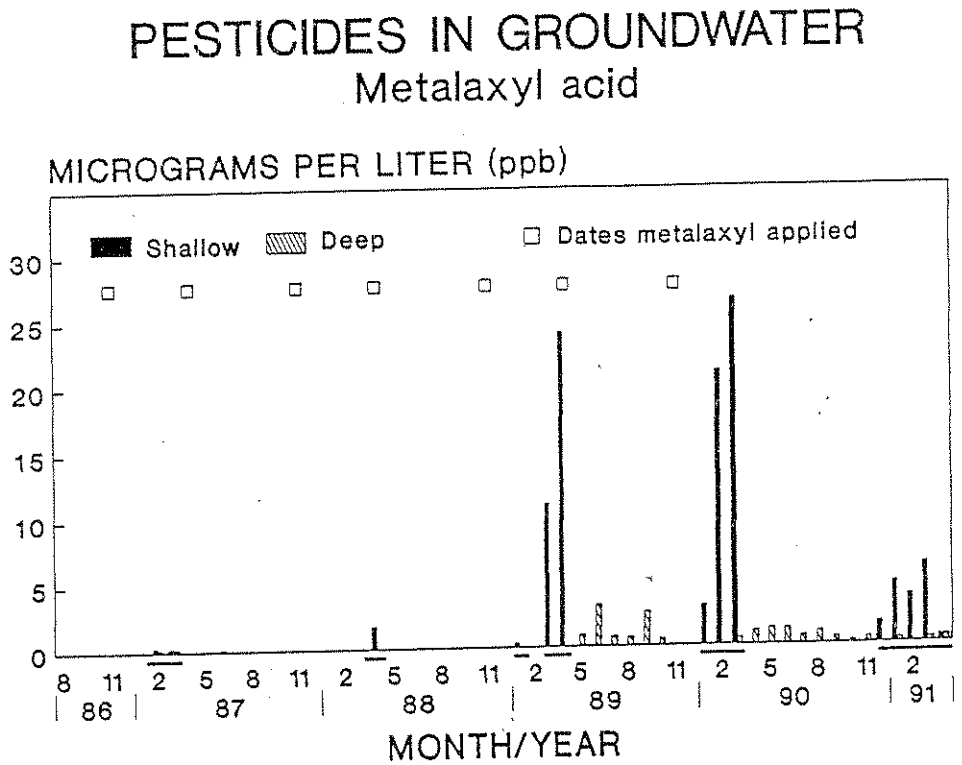
DATA NOT FOR DISTRIBUTION OR PUBLICATION

Figure 1.



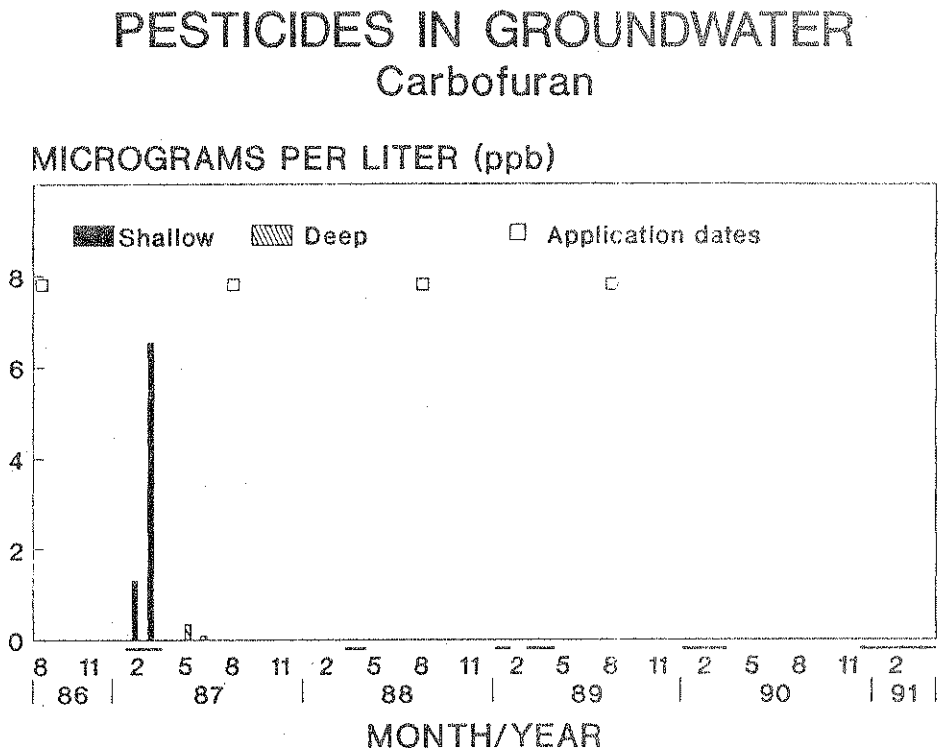
Farm 5 - Raspberry

Figure 2



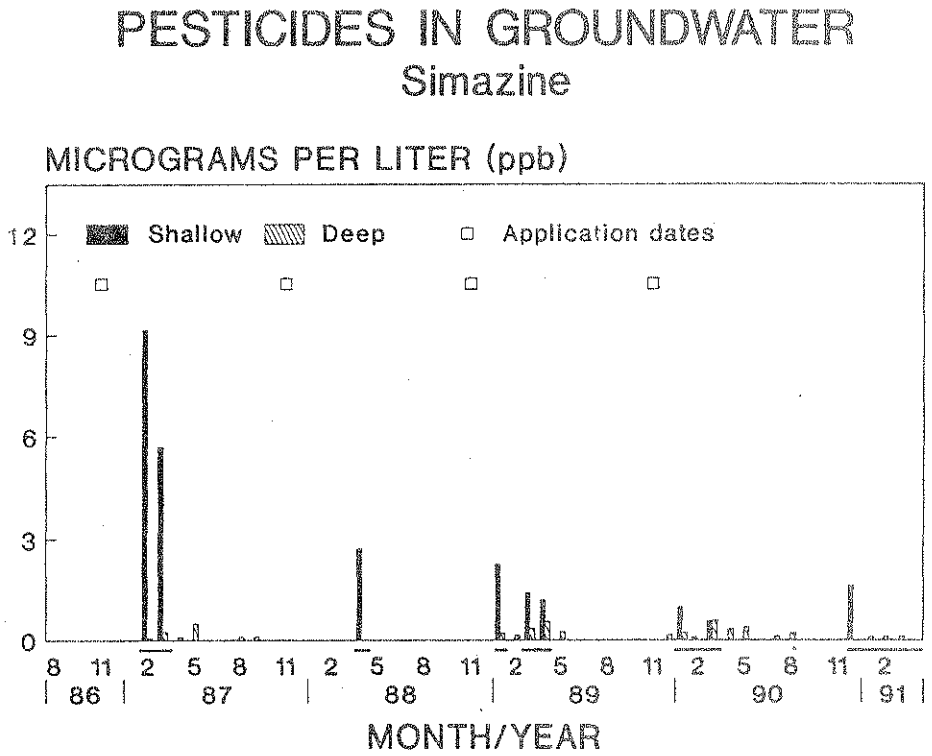
Farm 5 - Raspberry

Figure 3.



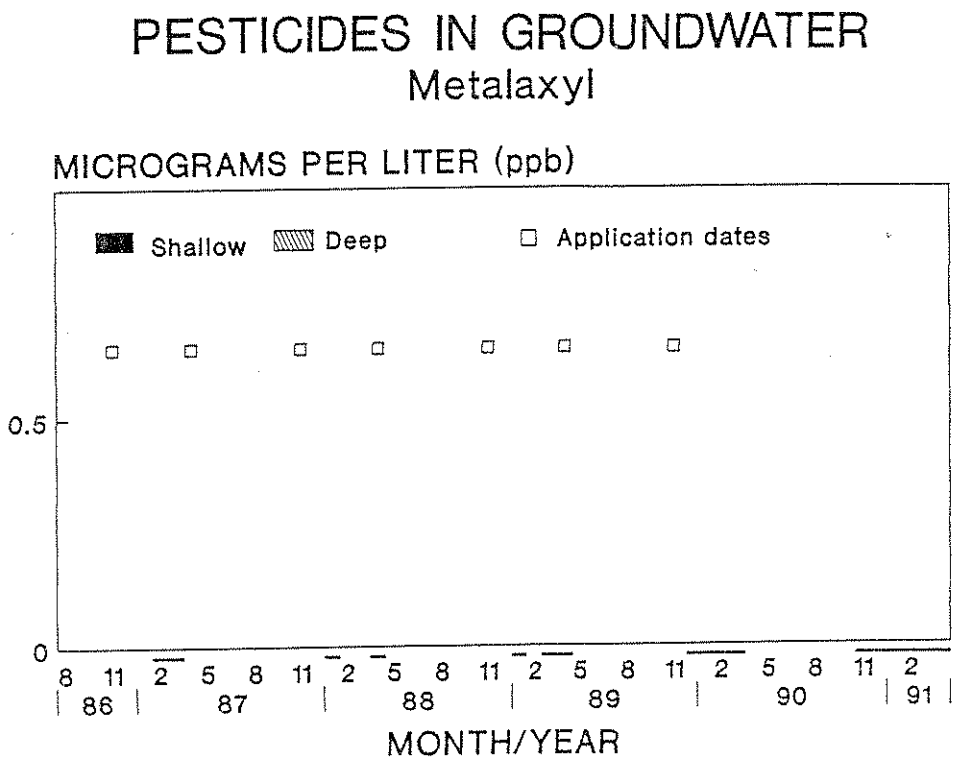
Farm 5 - Raspberry

Figure 4.



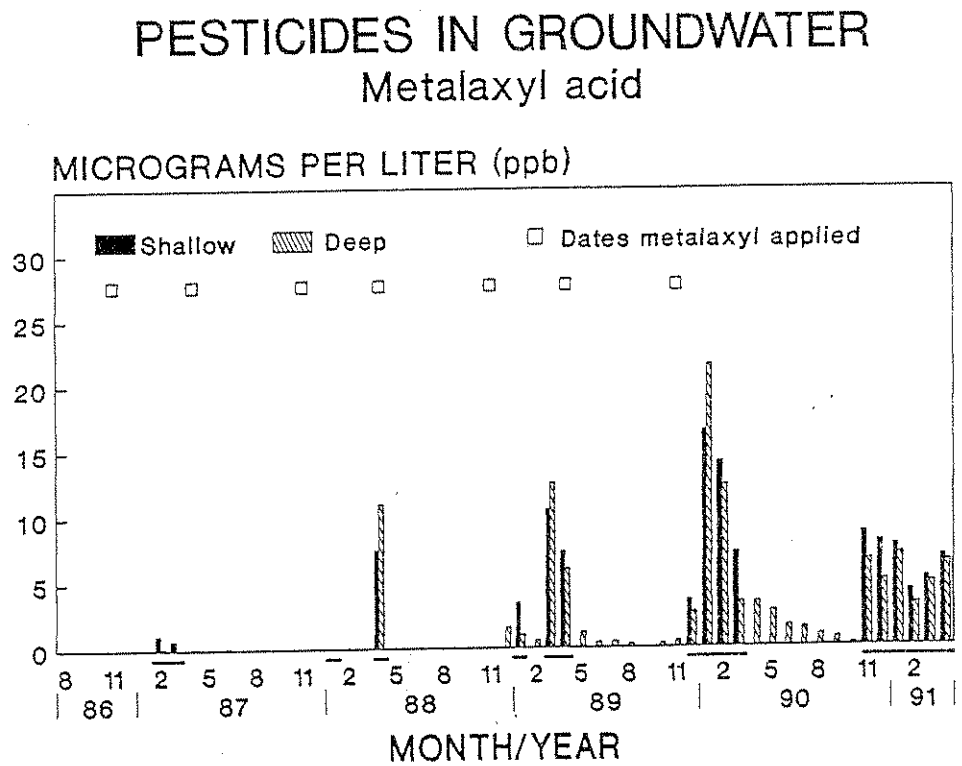
Farm 5 - Raspberry

Figure 5.



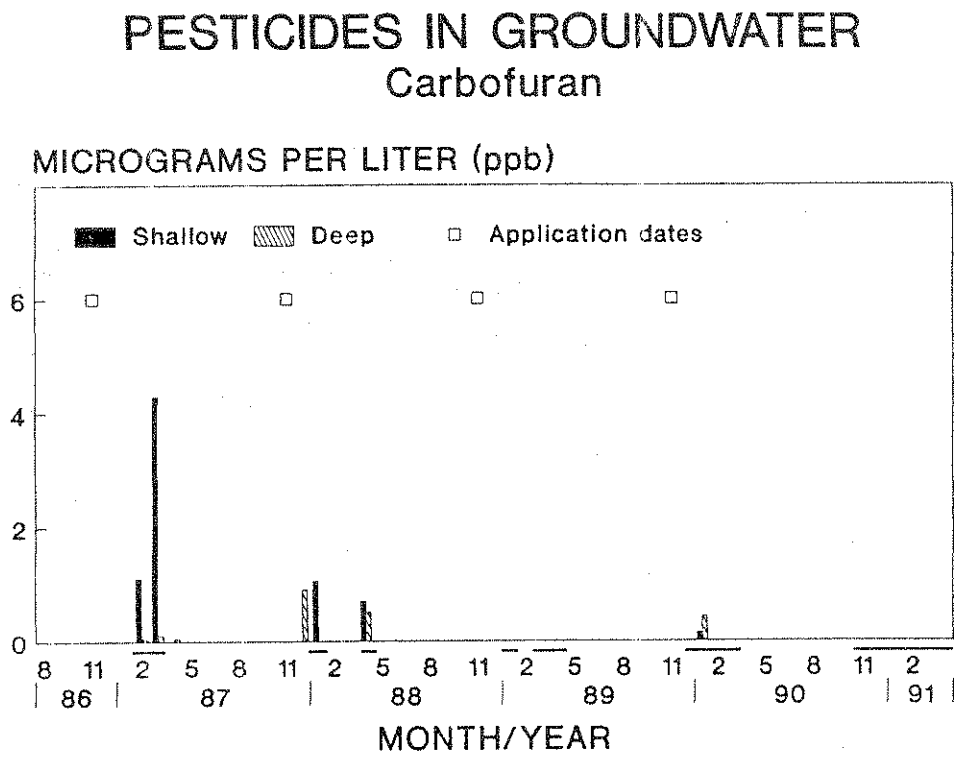
Picha Farm - Raspberry

Figure 6.



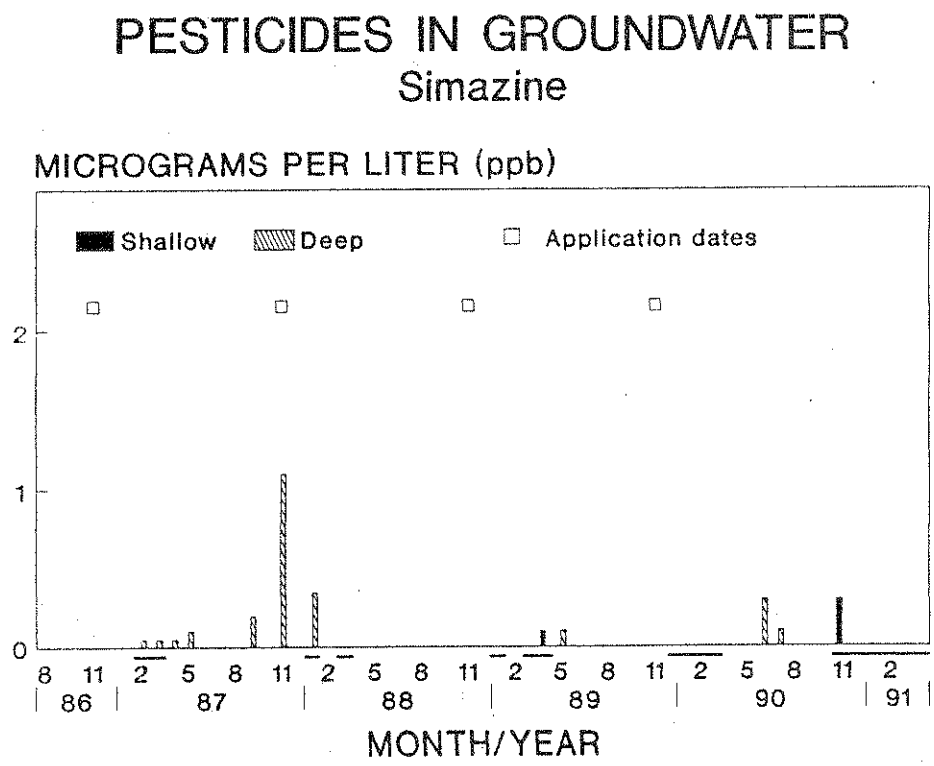
Pich Farm - Raspberry

Figure 7.



Picha Farm - Raspberry

Figure 8.



Picha Farm - Raspberry

PROJECT NO.: 13C-3761-2763

TITLE: Reaction of red raspberry cultivars and advanced selections to the root rot controlling fungicide Ridomil

PERSONNEL: Peter R. Bristow, Associate Plant Pathologist and
Patrick P. Moore, Assistant Horticulturist,
WSU Puyallup Research and Extension Center

JUSTIFICATION:

Previous research has shown that the yield of 'Sumner' and other selections increased when the soil was treated with Ridomil to control root rot caused by the soil-borne fungus *Phytophthora erythroseptica*. 'Sumner' and those selections are resistant or at least moderately resistant to root rot caused by this pathogen. The positive response to Ridomil indicates that root rot is causing damage to resistant cultivars and selections even though there was minimal cane death and wilting. In short, resistance is not complete and maximum yield potentials are not being realized when plants are infected. Recent selections, which exhibit no obvious symptoms of root rot, may similarly sustain yield losses when infected. Comparing the yields of Ridomil-treated and untreated plants will help determine the true yield potential of those selections.

OBJECTIVE:

To evaluate the performance of cultivars and advanced selections in both the presence and absence of Ridomil on a site naturally infested with *P. erythroseptica*.

PROGRESS:

Replicated plots of 12 cultivars and advanced selections were established in a naturally infested soil at the WSU-Vancouver Research and Extension Unit during 1990. Paired plots were used with one being treated with the fungicide Ridomil twice yearly (spring and fall) according to label instructions and the other untreated. Canes were mowed off after the 1990 season. Table 1 contains data on primocanes grown in 1991. These canes will be tied to the trellis and harvested for the first time in 1992.

For resistant cultivars or selections, except WSU 1007, there was little difference between untreated and Ridomil-treated plants. This indicates that their level of resistance is high. WSU 1007 is actually susceptible and was probably an escape when previously tested for resistance.

PROPOSED RESEARCH:

Cane height and diameter measurements will be taken in late fall 1991 and the sturdiest canes (up to 12 per hill) will be tied to the trellis. All plots will be mechanically harvested in 1992 with a Littau self-propelled harvester. Yield and berry size information will be obtained. Data on cane growth and root rot severity will also be collected in 1992. The plots will be maintained and Ridomil treatment continued for harvest in 1993.

TERMINATION OF BASE PROJECT: Project 0640, June 30, 1994

PROJECT DURATION: 3/4

BUDGET:

	1991-92 Last year	1992-93 Proposed year
Wages (timeslip)	$ 190.00	$ 1,500.00
Supplies and Services	400.00	100.00
Travel		80.00
Employee benefits	10.00	120.00
Total	$ 600.00	$ 1,800.00

Table 1. Response of red raspberry genotypes to Ridomil.

Genotype	No. primocanes/hill		% Wilted[x]		Primocane ht, cm[w]	
	Untreated	Treated	Untreated	Treated	Untreated	Treated
Cherokee (R)[z]	22	21	2.0	2.1	83	88
Newburgh (R)	24	30	7.5	0.4	96	100
WSU 1002 (R)	19	29	12.5	1.2	81	84
WSU 892 (R)	28	29	16.0	0.0*	103	114
WSU 1001 (R)	37	57*[y]	16.5	2.6*	113	120
Chilliwack (I)	20	32*	32.0	1.4*	116	142
Willamette (S)	26	44	32.1	0.9*	94	124
Tulameen (I?)	9	23*	37.3	0.6*	81	139*
Comox (S)	16	18	60.7	1.0*	58	116*
Meeker (I)	12	26*	68.3	3.3*	66	122*
BC 8028/50 (S)	3	31*	68.7	2.7*	68	117*
WSU 1007 (R)	18	34	90.5	2.7*	57	128*

[z] Reaction to root rot: R=resistance; I=intermediate; and S=susceptible (Reaction for WSU 892 determined at Farm No. 5).

[y] * = significant (P=5%) difference between untreated and treated.

[x] Data collected 14 Aug 91.

[w] Data collected 2 Jul 91.

PROJECT NO.: 13C-3543-2857

TITLE: The impact of overwintering native predators on spider mite populations in red raspberry fields.

PERSONNEL:

Carl H. Shanks, Jr., Entomologist, WSU-Vancouver.
Arthur H. Antonelli, Extension Entomologist, WSU-Puyallup.
Bruce D. Congdon, Associate Professor of Biology, Seattle Pacific University.

JUSTIFICATION:

The twospotted spider mite *Tetranychus urticae* Koch, in high numbers can cause early defoliation of red raspberries. This can result in abnormal bud-break in the fall and greater susceptibility to freeze injury in the winter.

Mite populations are very sporadic. Research in the past three years has shown that some fields had high or low mite populations every year while others had very low populations for two years and high numbers the third year. High mite populations were related to heavy use of insecticides in most cases but not in all. We hypothesize that, in many cases, the mite populations were kept low by predators which overwintered in raspberry fields or at their margins and were present early in the season in numbers too low for dependable counting. One strong candidate for this role is the small black lady beetle, *Stethorus* sp., but there are other possibilities. Confirmation of this hypothesis and knowledge of the species involved could lead to management practices that would conserve mite predators and encourage their overwintering in the raspberry fields.

OBJECTIVES:

1. Develop a trap that can be used to monitor over-wintering predators.
2. Quantify and study early season predator populations.

3. Determine the relationship between overwintering and early season predator populations and subsequent summer spider mite densities.

4. Determine the effect of insecticides on *Stethorus numbers. (added for 1992-93)*

PROGRESS: Objective 1. "Pleated burlap" overwintering arthropod traps were placed in 5 fields on September 2, 1990 and recovered on January 4 and 10, 1991. Probably due to unusually heavy rains and resulting flooding of fields, the number of *Stethorus* caught was negligible. This technique was therefore judged unreliable for making comparisons between seasons. The apparent "failure" of this attempt to measure overwintering *Stethorus* populations was compensated by the success, continued in the second year of study, of efforts to monitor early-season predator populations as they emerge from overwintering.

Objective 2. "Trap colony" assessment of *Stethorus* populations continued unmodified for a second year. The results were consistent with those of the first year of the study and add support to the tentative conclusion that low densities of *Stethorus* have an important impact on spider mite populations early in the season. Specifically . . .

1. Analysis of trap colony data demonstrated that there is no significant effect of the number of spider mites in a trap colony (artificial infestation) on the frequency or probability of attack by *Stethorus*. This is important to any subsequent conclusions drawn from trap colony data, since the mean number of spider mites on trap colonies varied considerably from site to site and from date to date. This analysis basically shows that all the trap colonies are equally "attractive" to *Stethorus*. Therefore, we judge the trap colony technique to be a reliable indicator

of *Stethorus* activity in the early season when conventional techniques lead to the conclusion that this predator is absent.

The biological importance of these observations should not be overlooked. They suggest that *Stethorus* adults are highly effective searchers, apparently capable of surviving at very low prey densities. It is also possible that relatively low populations of this predator are capable of preventing any economically important increase of spider mite populations, both by its voracious consumption of spider mites and its ability to remain in a field when prey is scarce.

2. *Stethorus* adults have been detected in trap colonies as early as May 4 in many fields and at some time in every field sampled during the two-year study. *Stethorus* adult populations, as indicated by trap colonies, varied in density from field to field, but uniformly drop off to virtualy zero after the end of June. However, the number of *Stethorus* eggs in trap colonies appears to correlate with both time of year and spider mite density in the field as measured by leaf samples. In general, most *Stethorus* oviposition occurred around or following June 30, or earlier when there were measurable spider mite populations present earlier in the season.

Objective 3. The relationship between *Stethorus* populations and peak spider mite densities will be difficult to determine. Our 1991 studies contributed to the objective, but this aspect needs to be continued.

1. Spider mite densities increase in most fields in middle to late August. The relationship between the magnitude of this increase and *Stethorus* activity through the early and mid-season remains unclear. The observation that *Stethorus* reached high densities only in fields where trap colony egg counts were low after mid-July may be misleading. In those fields where spider mites are on the increase, trap

colony catches of both eggs and adults of *Stethorus* plummet, since the trap colonies are competing with high natural mite populations. Furthermore, there is no obvious direct relationship between early season *Stethorus* activity levels and the final outcome of the spider mite population increase in the late season.

2. Two important conclusions can be made from the first two years of this study. A) *Stethorus* is one of the major agents of biological control of spider mites in raspberries, since it apparently attacks with great efficiency the already scarce spider mites early in the growing season. We suspect that this means that the starting point for spider mite population growth later in the season is depressed, and this may account for the lower late-season peaks in spider mite density in some fields. Our data set is not complete enough at this point to come to a firm conclusion on this point. Predatory mites, on the other hand, are consistently present only in a few fields, and they appear not to exert control on spider mites. They are most abundant in fields with chronically high spider mite numbers and conspicuously absent from several fields with consistently low numbers. B) Peak spider mite densities are the result of more than simply the abundance of predators in the field at the beginning of the season. Other factors which may be important are the ratio of predators to spider mites (which may be the result of spider mite density in the previous season) and the influence of cultural practices and cultivar characteristics on spider mite survival and development. We need to continue following the population trends in these fields to determine whether some are just more prone to spider mite attack, or whether the predator-prey system requires several years to become stable following a history of disruption by pesticides.

PROPOSED RESEARCH:

Objective 3. Our 1991-92 research will focus on this objective. We propose to continue monitoring the same fields to assess whether stability may develop over several years, leading eventually to successful biological control of spider mites by *Stethorus*, or whether certain cultural conditions appear to put his predator at a consistent disadvantage in some fields.

Objective 4. Blocks of raspberries will be divided into two sections. Trap-colonies of spider mites will be placed on leaves at locations across the entire width of each block to determine the population size of *Stethorus* in each block. One section of each block will be sprayed with a short-lived insecticide to kill the *Stethorus* in those sections. Then new traps will be placed at the same locations in each section a few days after spraying and at weekly intervals thereafter. This should show how quickly *Stethorus* can migrate across a field and repopulate it.

TERMINAL DATE OF BASE PROJECT: March 31, 1994.

DURATION OF THIS PROPOSAL: This will be the third of 3 years.

BUDGET:

		1991-92 Last year	1992-93 Proposed year
01	Wages	$7,000	$8,100[a]
03	Supplies	500	100
04	Travel	1,500	1,000
07	Benefits	350	648
	Total	$9,350[b]	$9,848

[a] $6,000 for 2 months research by Ph.D. entomologist, $2,100 for student assistant.
[b] The final amount awarded was $7,350.

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PROJECT NO.: 13C-3555-2783

TITLE: **Advanced testing of new compounds for caneburning of red raspberry**

PERSONNEL: **J. Scott Cameron**, Assistant Horticulturist
Chuhe Chen, Postdoctoral Research Associate
Washington State University Research and Extension Unit, Vancouver
Carl Libbey, Research Technologist II
Washington State University 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. Research programs in Washington, Oregon, and British Columbia have been seeking to register effective alternatives to dinoseb. The efficacy of a compound in suppressing primocane growth is not the only factor which must be considered in selecting a caneburning method for commercial use. The effects of such compounds on productivity and long term growth and development must also be tested. The purpose of this project is to thoroughly evaluate the influence of these potential caneburning compounds on the productivity, growth, and development of red raspberry.

OBJECTIVES:

1. Evaluate cane suppression characteristics and yield component relationships associated with the use of new caneburning compounds.
2. Study the long term effects of using these compounds on productivity, growth, and development of established red raspberry plantings.
3. Gain a better understanding of the primocane suppression process and the plant's response to fruit load and compensatory relationships relative to primocane management.

PROGRESS: In 1991 this project continued with a fourth year of testing of dinoseb alternatives in replicated plots at Vancouver and Mt. Vernon. Oxyfluorfen (tradename Goal) was applied once to newly emerging primocanes at five different rates: 0.1, .2, .4, .8, and 1.6 lbs/A. Multiple application treatments were also tried. Other treatment groups included one receiving two applications of dinoseb and an untreated control. There are two primary goals of this research. One is to screen and register promising dinoseb alternatives for primocane suppression. A new, dinoseb-alternative compound (Uniroyal C4345) has also been put into this trial and appears promising. Horticultural and physiological evaluations of primocane suppression and crop response (short and long term) are ongoing. The second goal relates to studies which have been undertaken

in order to better understand the primocane suppression process and the plant's response to fruit load and compensatory relationships relative to primocane management.

After obtaining Section 18 status for oxyfluorfen in 1990 and 1991, emphasis has been placed on oxyfluorfen in 1991 as we proceed with the registration process for that material. Two aspects of primocane management are being considered. In considering chemical/rate combinations, one aspect is that of primocane suppression and the other is that of regrowth and long-term productivity. As can be seen in Figure 1, yield per cane is a function of berry number and berry size, but repeated use of higher rates of oxyfluorfen tends to reduce primocane number and size, thus weakening the planting and reducing overall productivity.

Studies have been undertaken in order to understand the primocane suppression process and the fundamental vegetative/reproductive relationships which precipitate the need for chemical primocane management. For example, one study involves collecting primocane diameter and height data on a weekly basis in order to obtain primocane growth curves from northern and southern regions of Western Washington. This study is providing information as to patterns of primocane growth during the season as influenced by chemical primocane management compared to untreated controls. In general, as the rate of oxyfluorfen applied increases, the longer the delay of primocane regrowth, and thus the next year's fruiting cane is reduced in size. In Figure 1, four years of low rates of Goal suppresses primocane emergence in the Spring and allows primocane regrowth equivalent to untreated controls. Four years of Goal at 1.6 #/A was similar to four years of dual applications of dinoseb. This underscores the fact that repeated use of dinoseb in PNW raspberry fields may have been robbing many of our fields of vigor and productivity.

The carbon dynamics of primocane suppression are also being studied. After four years of oxyfluorfen treatment, samples for analyses of leaf anatomy, starch quantification/deposition, and protein assays/SDS polyacrilamide gel electrophoresis were taken approximately during anthesis, green fruit, red fruit and postharvest stages. These assays will qualify and quantify characteristics of carbon dynamics during the fruiting process and as a result of primocane suppression. Initial results indicate that the source-sink relationships between primocanes and fruiting canes which have been assumed for many years may not be totally accurate. While it has been assumed that developing primocanes act as a competing sink for photoassimilates in detriment to fruit development, they may actually provide photoassimilates during the peak of fruit development but later compete for resources such as light, thus halting or delaying fruit development in certain portions of the canopy.

Studies in fruiting physiology are also being conducted in order to better understand inter/intraplant competition and the biology of primocane suppression. Dawn to dusk measurements of carbon assimilation, fourth derivative spectroscopy, total protein and leaf anatomy/starch deposition are being made at critical stages from flowering through

postharvest in order to quantify assimilate demand relationships influenced by primocane development and compensation potential of the plant. This information will allow us to develop a model of how the red raspberry plant harvests light energy, assimilates and partitions carbon, and maximizes productivity. Such a model will eventually integrate the cumulative influence of environmental and cultural stresses which reduce red raspberry productivity.Our data clearly shows that the label rate of 0.2-0.4 lbs/A still provides the optimal balance among primocane control, primocane regrowth and subsequent yield. Careful evaluation of plant performance over the next several years will ultimately determine the economic and physiological costs of our current use pattern of oxyfluorfen.

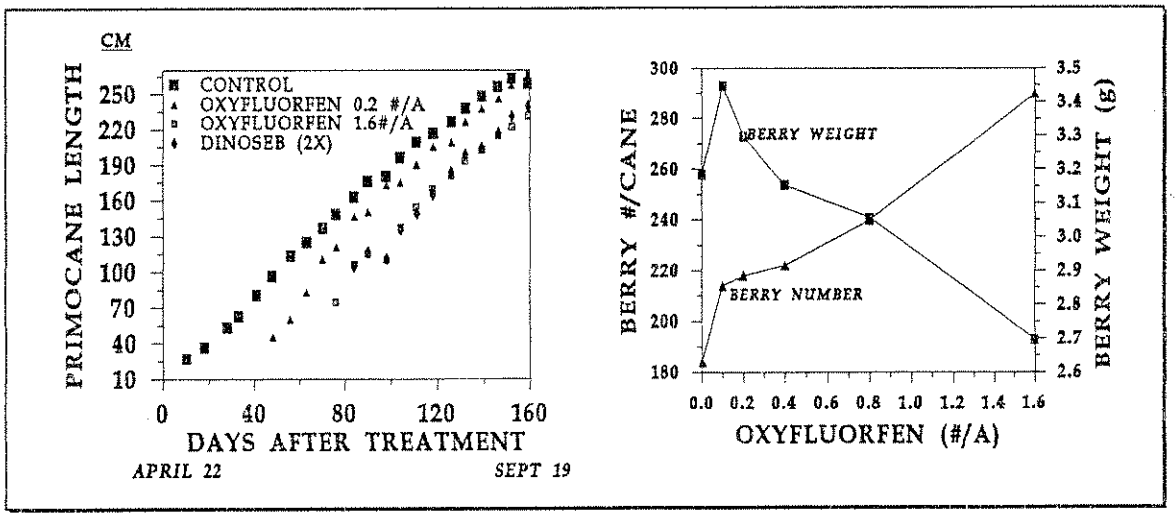

Figure 1. After four years of application of oxyfluorfen for primocane suppression, primocane emergence is delayed and regrowth is reduced. The relationship between berry number and berry weight is also influenced.

PROPOSED RESEARCH: In 1992, the same experiment will be repeated at both sites in the same plots. The primocane suppression characteristics of each treatment combination will be rated, and, during harvest, yield component measurements will again be made in order to assess the influence of these chemicals on the yield potential of red raspberry. Fruit quality factors may also be evaluated where deemed appropriate. The 1992 season will allow us to continue moving forward with the registration process while evaluating the potential problems associated with the long-term use of these materials.

Primocane regrowth will again be studied in northwestern and southwestern Washington. Weekly measurements of primocane length and diameter will be made in order to model the growth of primocanes as a function of primocane suppression practices.

In order to effectively design primocane suppression strategies in red raspberry, the biology of primocane development and its influence on productivity will be a continuing focus of study. A major need in this regard is to determine at what time (s) during the season the presence of primocanes actually alters source/sink relations. This research would involve measurements of photosynthetic response, fourth-derivative spectroscopy of photosynthetic action spectra, SDS polyacrilamide gel electrophoresis, and anatomical studies. If anticipated improvements are made to our laboratory in the coming months, we will be able to use radioactive labels to study source/sink relationships in the vegetative and fruiting phases of the raspberry plant at different stages of development. These studies will also help to characterize the biochemical and physiological consequences of short-term and long-term use patterns with this very potent herbicide.

TERMINAL DATE OF BASE PROJECT: 10A-3555-0783; June 30, 1993

DURATION OF THIS PROJECT: Second year of a three year project. Oxyfluorfen is currently the only primocane control chemical which has potential for registration and other materials are being screened as they become available.

BUDGET:

		Request 1991	Funding 1991	Request 1992
01	Temporary employees	$6,000	$3,000	$4,000
03	Supplies and services	800	400	480
05	Computer services	350	350	300
06	Travel	350		300
07	Benefits (5% of 01)	300	150	320 (8%)
	TOTAL	$7,800	$3,900	$5,400

PROJECT NO.: 13C-3555-5783

TITLE: **Leaf/fruit ratio and yield potential in red raspberry**

PERSONNEL: **J. Scott Cameron**, Assistant Horticulturist
Chuhe Chen, Research Associate\Visiting Scientist
Stephen F. Klauer, Agricultural Research Technologist II
Washington State University Research and Extension Unit, Vancouver

JUSTIFICATION: In tree fruits such as apple and cherry, it is known approximately how much leaf area is required to produce a fruit. This information has been extremely useful in developing a scientific approach to canopy design and cultural management. There are no published reports concerning leaf area/assimilate demand relationships in red raspberry; this type of information would be very useful in determining the yield potential of this crop. This in turn would aid in implementing new strategies to increase the efficiency of red raspberry culture, and provide valuable information concerning the influence of physiological stresses such as those caused by diseases and insects on the productivity of red raspberry.

OBJECTIVES:

1. To characterize the influence of fruiting on the physiology of red raspberry over the course of the season.
2. To determine the influence of leaf:fruit ratio on carbon dynamics of red raspberry.
3. To model the yield potential of red raspberry.

PROGRESS: In 1988, we found that higher photosynthetic rates were associated with lower leaf:fruit ratios. Smaller unifoliate leaves directly subtending fruit had higher photosynthetic rates than larger trifoliate leaves subtending the entire node. In 1989-91 we continued this project by following the development of leaves on fruiting and defruited canes. Leaves from fruiting and nonfruiting canes were sampled for physiological and anatomical analyses over the entire season or during critical developmental stages. Fourth derivative spectroscopy, gas exchange, chlorophyll, dry weight per unit leaf area, SDS PAGE, and anatomical analyses were conducted. In 1991, diurnal analyses were also conducted at three major developmental stages: the period shortly after bloom, during fruit development and the postharvest period.

The gas exchange rates of leaves from fruiting (F) and deflowered (DF) canes of 'Meeker' red raspberry were compared during fruit development. Leaves on F laterals had carbon dioxide assimilation (A) rates significantly ($p<.01$) higher when green (87%) and red (22%) fruit were present, but rates of A were similar after harvest.

During this time, leaves on DF laterals had greater dry weight accumulation as well as greater chlorophyll a (chl_a) and total chlorophyll (chl_t) content compared to leaves on F laterals. Accumulated attenuance and fourth-derivative spectra of leaves from F and DF canes were compared. Peak wavelengths were similar, but variation was noted in peak amplitudes.

Unifoliate leaves subtending fruiting spurs had significantly higher ($p<0.01$) rates of A than larger trifoliate leaves subtending the entire lateral. Trifoliate leaves subtending F laterals had higher chl_a and chl_t content than unifoliate leaves on F laterals. Leaves at each node along F laterals had significantly higher rates of A than did corresponding leaves on DF laterals. Photosynthetic activity decreased 60-70% in leaves along the lateral between the exterior and interior portions of the canopy.

We have demonstrated that raspberry leaves accumulate starch during the late morning hours and leaf starch content declines until late afternoon when an early evening increase is followed by a decline overnight. Photosynthetic behavior over the course of the day shows a corresponding type of pattern as peaks occur in early morning and early evening during fruit development (Figure 1).

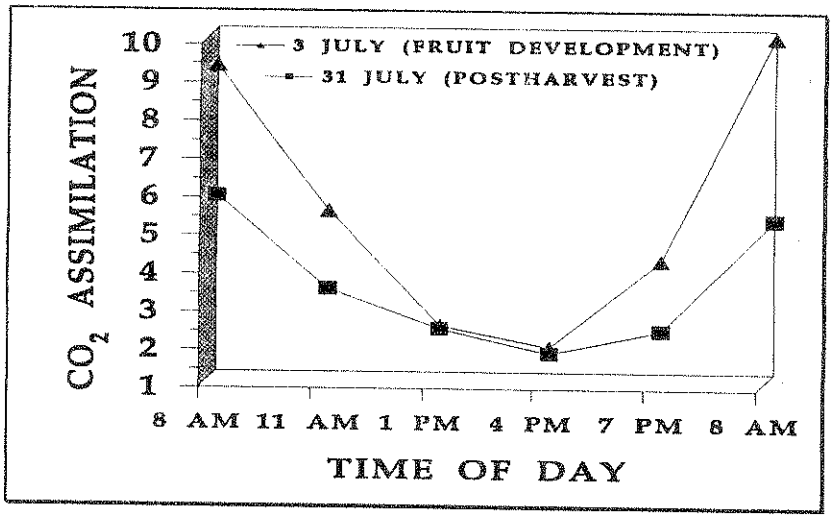

Figure 1. Photosynthetic profile of raspberry leaves on fruiting canes over the course of the day during fruit development and after harvest.

After bloom, photosynthetic rates begin to increase, peak during fruit development and then drop to their lowest point after harvest. Leaves on fruiting laterals accumulate starch prior to the presence of green fruit. Three to five weeks after anthesis as fruit expand and then ripen, leaf starch decreases significantly. This supports our observation that the presence of fruit increases CO_2 assimilation due to increased assimilate demand. Leaves on nonfruiting laterals do not show these behaviors.

The importance of this information becomes clear when one considers how far we

are from harvesting the actual yield potential of the red raspberry plant. 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 a certain number of canes bearing a certain number of fruit per cane of a given size. Our research is characterizing the plant's response to changes in this yield component relationship so that we can determine the limitations to yield we currently face as a result of our cultural system and stress imposed by weather and pests.

PROPOSED RESEARCH: In 1992, we will continue to model the response of red raspberry to assimilate demand by repeating certain parts of our previous studies. We have developed a general, practical, yet scientific overview of physiological compensation in red raspberry. We seek to continue this work in an effort to create mathematical models which will help us to develop strategies for reaching the yield potential of this crop through more intelligent management of red raspberry growth and development. In 1992 we will attempt to better define the limitations to yield which occur within a single cane with regard to fruit size and number. These relationships will be merged with physiological analyses in order to find the mechanism(s) by which the plant responds to stresses imposed during assimilate demand. Physical improvements made to our laboratory in 1992 will hopefully allow us to undertake studies in which radioactive tracers will tell us how the plant takes in carbon dioxide and how fixed carbon is allocated to fruit.

TERMINAL DATE OF BASE PROJECT: June 30, 1993

DURATION OF THIS PROJECT: Second year of a three year project. We are continuing to develop a working model of red raspberry carbon dynamics which can be used for optimizing cultural and pest management strategies.

BUDGET: Funding is primarily used for labor-intensive analyses of plant material, data collection, supplies and computer-based mathematical analyses.

	1991		1992
01 Temporary employees	$2,500		$2,500
03 Supplies and services	175		600
05 Computer services	700		300
07 Benefits (5% of 01)	125	(8%)	200
TOTAL	$3,500		$3,600

PROJECT NO.: 13C-3555-5956, *FINAL REPORT*

TITLE: **Phenotypic stability and field performance of micropropagated red raspberry cultivars**

PERSONNEL: **J. Scott Cameron**, Assistant Horticulturist
Stephen F. Klauer, Agricultural Research Technologist II
Washington State University Research and Extension Unit, Vancouver

JUSTIFICATION: Micropropagated plants often have altered phenotypes (behavior) compared to conventionally-propagated plants of the same cultivar. Increases in vigor and productivity as well as differences in morphology have been reported in micropropagated strawberries, thornless blackberries, and blueberries. While small fruit breeding programs and commercial nurseries continue to rely on *in vitro* propagation methods, questions concerning the genetic stability and field performance of these plants remain unanswered. Temporary alterations in phenotype could require new selection strategies for breeders and modified cultural management for growers. There are currently no guidelines for our industry on how to handle micropropagated planting stock, and to date, there have been no published reports of field performance trials of micropropagated red raspberry plants.

OBJECTIVES:

1. To compare the field performance of micropropagated 'Willamette' plants to those conventionally-propagated from micropropagated foundation stock after one and two years in the field. Evaluate the potential of micropropagated planting stock.
2. To determine what characteristics of micropropagated plants are expressed during establishment which may make them more productive than conventionally-propagated plants.

PROGRESS: Micropropagated (MP) plants of 'Willamette' and 'Meeker' were established in a replicated planting with plants conventionally propagated (CP) from MP plants after one and two years in the field. Difficult first year (1987) establishment of micropropagated (MP) plants raised questions concerning the handling of MP planting stock. The questionable response of these plants to heat and low soil moisture as well as potential sensitivity to Ridomil (possible phytotoxicity) in our planting raised concerns. Similar observations of MP raspberry plant sensitivity to preemergent herbicides have been made in New York (M. Pritts, personal comm.) These researchers also designed treatments which manipulated soil moisture and temperature, demonstrating that MP raspberry plants require a different set of management practices during establishment.

These factors must be examined relative to any advantages conveyed by differences in growth and development of MP plants during establishment, such as increased cane

numbers or lateral branching. In 1989-90, our field trials demonstrated that yield potential was slightly (5%) higher for MP plants compared to their CP counterparts.

Another part of this project was accomplished between 1989-91. MP and dormant, CP plants (24 of each) of 'Centennial' red raspberry were planted into 57 liter pots of field soil and established in the greenhouse. In the early spring, pots were brought outside and half of the plants of each propagation type were pruned back to several inches above the soil line in order to simulate mowing. At the end of August, all pots were analyzed for total cane number, and each of nearly 1100 canes was measured for length, diameter, and node number. In some of the blocks plants were divided into their component parts and dried for partitioning analysis.

No differences were observed in the amount of total dry matter accumulated or its allocation to leaves, roots or stems in MP and CP plants. Similarly, mowing did not influence total dry weight or partitioning. Propagation method and mowing, however, strongly influenced plant growth habit and architecture. MP plants had nearly twice as many canes per plant, but they were slightly smaller. Mowing increased cane size but not cane number. It appears that some growers were correct in assuming that mowing MP plants enhanced their establishment after planting.

In 1991, plants were pruned to eight canes per pot and trellised as in the field. Yield component analysis was performed. Mowing increased total dry weight of MP canes, although CP canes weighed more than MP canes. While mowing increased numbers of fruit and fruit size for MP and CP canes, CP canes produced more fruit and larger fruit compared to MP canes. MP canes fruited earlier and finished fruiting sooner than CP plants. While yield potential is higher for MP plants, it is due to having more canes than CP plants. Higher potential yield spread over more canes with smaller fruit is not an advantage if that increase in yield is pruned out during cane thinning. As in other crops, micropropagation alters the behavior of raspberry plants primarily for one season. The resulting differences in plant architecture can enhance establishment and productivity, but further research is needed to establish optimal timing of planting and mowing.

TERMINAL DATE OF BASE PROJECT: June 30, 1993

DURATION OF PROJECT: While this would be the second year of a renewed, three year project, we have decided to withdraw the project before it begins a new phase as we feel that there are other more pressing research needs for industry support. We have learned much from this project and greatly appreciate the support of the Commission.

BUDGET:

		Request	Funding	
		1991	1991	1992
01	Temporary employees	$2,600	$ 950	------
03	Supplies and services	670		------
05	Computer services	100		------
07	Benefits (5% of 01)	130	50	------
	TOTAL	$3,500	$1,000	------

PROJECT NO.: 13C-3555-4883

TITLE: **The influence of mite feeding and miticide applications on the growth and physiology of red raspberry**

PERSONNEL: **J. Scott Cameron**, Assistant Horticulturist
Carl H. Shanks, Jr., Entomologist
Stephen F. Klauer, Agricultural Research Technologist II
Chuhe Chen, Research Associate\Visiting Scientist
Washington State University Research and Extension Unit, Vancouver

JUSTIFICATION: The two spotted spider mite, *Tetranychus urticae* Koch, is a sporadic and potentially serious pest of red raspberries. The actual influence of mite feeding and damage on the growth and physiology of red raspberry is poorly understood. While mite damage can cause defoliation and thus reduce winterhardiness, it is less clear as to what influence mite damage might have on overall growth and ultimately yield. In 1988 we were able to demonstrate that the damage caused by mite feeding on red raspberry leaves was capable of reducing photosynthetic rates as much as 60%. It was also observed that significant reductions in photosynthesis occurred without the presence of visible damage to the leaves. This information has not been considered in determining the economic threshold for the control of mites, and determining the magnitude of this response would provide hard data for setting an accurate threshold for more efficient control of this pest.

Similarly, it has been observed that certain types of pesticides can have a negative influence on the physiology of plants, and it has been suggested that some miticides may have such an effect on strawberry. It would be valuable to know if such an influence occurs in red raspberry, and if the combination of mite feeding and miticide applications can cause significant reductions in the photosynthetic potential and the growth of this plant.

OBJECTIVES:

1. To determine the influence of mite feeding and miticide applications on the physiology of red raspberry.
2. To evaluate economic damage thresholds in light of plant response to limited mite feeding.
3. Evaluate native and cultivated *Rubus* for response to mite feeding.

PROGRESS: We have previously demonstrated that mite populations were compared with gas exchange characteristics prior to visible leaf damage, carbon dioxide assimilation rate (photosynthesis) and mesophyll conductance were negatively

correlated with mite number per leaflet. After physical damage to leaves was apparent, mite number per leaflet was correlated with all gas exchange parameters as well as chlorophyll content. The significance of this observation is that the initial depression in photosynthetic processes appears related to some factor which influences the biochemistry of photosynthesis. As mite populations peak and leaves become physically damaged, declines in chlorophyll content and stomatal control also depress photosynthesis. Under the conditions of our experiment, the threshold at which chemical control is recommended, 25 mites per leaflet, photosynthesis was reduced by 20%.

In 1990, the influence of miticides on photosynthesis was tested using Vendex and Kelthane on plants in the greenhouse. Vendex and Kelthane are the only miticides currently registered for use in Washington on red raspberry. Kelthane is known to have potential phytotoxic effects on some plants. After one hour, both chemicals reduced photosynthesis compared to unsprayed controls, Vendex by 11%, and Kelthane by 24%. After four hours, photosynthesis in Vendex-treated leaves recovered to the level of the controls, while Kelthane-treated leaves were reduced by 28%. After seven hours, Kelthane dropped photosynthesis by 36%, improved to a 20% reduction after 24 hours, and recovered to the level of unsprayed controls after 48 hours. Fourth derivative spectroscopy showed no consistent indication of damage to photosynthetic reaction centers, perhaps due to sample variability.

In 1991, studies are currently being conducted in the greenhouse and growth chamber to test the influence of localized mite feeding on gas exchange of red raspberry leaves. A recently completed study attempted to discover how soon after infestation leaf gas exchange declines. Data are not yet fully analyzed, but it appears (Figure 1) that under the conditions of our experiment, that photosynthesis was lower in infested leaflets within six hours.

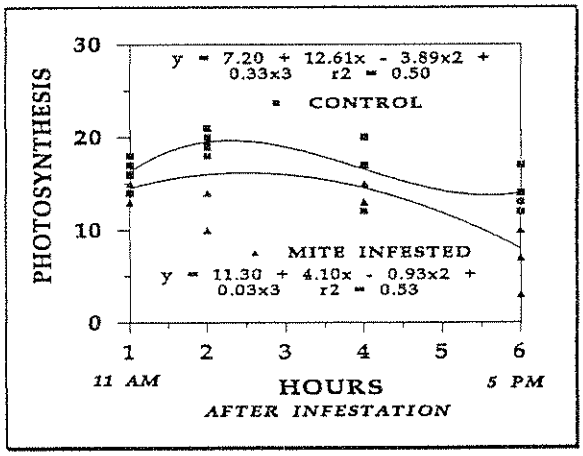

Figure 1. Photosynthetic response of red raspberry leaves to mite feeding over time.

PROPOSED RESEARCH: Experiments will be conducted which will examine the response of red raspberry physiology to limited mite feeding, *particularly with regard to mite number*, and whether miticides and mite feeding have an additive, negative impact on physiological processes. This will allow us to define economic thresholds from the standpoint of how the plant responds physiologically to mite feeding, and not just how the plant appears. We are currently working with limited mite feeding scenarios under controlled conditions in order to document the speed, distribution and duration of this influence. The possibility of a hormone-like message (as recently discovered in insect feeding on tomato) will be considered as the physiology of this plant-pest interaction is studied. Potted plants in the growth chamber and greenhouse will be used to allow for repetitive experiments and for uniformity of plant material and environment. Similar experiments are being designed for plants in the field. Leaves of fruiting and nonfruiting canes will be examined for the influence of localized mite feeding on carbon dynamics. Gas exchange measurements will be made using an ADC-LCA2 portable photosynthesis measurement system, proteins will be characterized using SDS-PAGE, and action spectra relationships quantified using fourth derivative spectroscopy.

TERMINAL DATE OF BASE PROJECT: June 30, 1993 (JSC)
March 31, 1994 (CHS)

DURATION OF THIS PROJECT: One year with the possibility of renewal depending upon the results obtained in 1992.

BUDGET:

		1991 Request	1991 Funding	1992 Request
01	Temporary employees	$1200		$1,500
03	Supplies and services	500	$ 500	1,000
05	Computer services	500		180
07	Benefits (8% of 01)	60		120
	TOTAL	$2,260	$ 500	$2,800

Project No:

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

Year Initiated: 1990 **Current Year:** 1992 **Termination Year** 1993

Personnel: Robert R. Martin, Agriculture Canada Research Station, 6660 NW Marine Dr., Vancouver, B.C. V6T 1X2, and Irene Bremsak, graduate student working on this project.

Justification:

Raspberry bushy dwarf virus (RBDV) is the most common virus disease of raspberries in the Pacific Northwest. Currently, only two raspberry cultivars (Willamette and Chilliwack) 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 plant virus coat proteins stablely 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. We have successfully carried out similar research with potato and have obtained very high levels of resistance in greenhouse trials.

Objectives:

This will be the second year of this project. To date we have developed diagnostics that will be required to test for the expression of the RBDV coat protein in transgenic raspberries. During the second year of this project we will identify and sequence the coat protein of RBDV which is a prerequisite to developing synthetic resistance. We will also work a useable transformation system for raspberry based on information obtained from the group at the Scottish Crops Research Institute. During the third year of the project the coat protein gene of RBDV will be put into several raspberry cultivars and these lines challenged with virus to evaluate their reaction to RBDV.

Progress:

To date we are developing the tools required for testing the transgenic plants. We have now prepared a number of specific monoclonal antibodies that will be useful for detecting the expressed gene in the raspberry plants. In my lab we have completed the transformation of

several potato cultivars with a virus coat protein gene and obtained high levels of resistance to the virus in potatoes. In the work with potato leafroll virus we have developed the techniques required to carry out this work. We have also developed some expertise in the transformation of plant tissue using Agrobacterium tumefaciens as well as experience with tissue culture of raspberry. We have now have a method to regenerate raspberry from leaf disks which is required before the plant transformation can be accomplished. We have prepared the coat protein gene of RBDV and are now in a position to incorporate this gene into raspberry plants.

Proposed Research:

The coat protein gene will be transferred to a disarmed Agrobacterium tumefaciens and from there the gene will be transformed into raspberry leaf disks. This the second year of this project and we will introduce the coat protein gene of RBDV into several raspberry cultivars. The transformed plants (plants with the coat protein gene inserted into the plant genome) will be tested for the presence of the inserted DNA, then checked to make sure the corresponding RNA is produced and that the gene is expressed and the coat protein is produced in the plants. Plants expressing high levels of coat protein will be graft inoculated with RBDV to test for resistance. In addition to these tests an application will be made to be allowed to plant these plants in the field to test for field resistance. Since we want to see a response in the field, initially we will want to use cultivars that are readily infected with RBDV in the field. Meeker will be our first choice of cultivar to work with.

Termination date of Base Project: Jan. 1, 1994.

Duration of this project: 2/4

Budget: 1992-93	1991-92	Proposed for 1992-93
03 Goods and Services	4500.00	5000.00
04 Travel		
TOTAL	4500.00	5000.00

PROJECT NO.: New

TITLE: Control of root weevils in red raspberries

YEAR INITIATED 1991, CURRENT YEAR 1992, TERMINATING YEAR 1994

PERSONNEL:

Carl H. Shanks, Jr., Washington State University, Vancouver.
John D. Stark, Washington State University, Puyallup.

JUSTIFICATION:

Root weevils, especially black vine weevil, are an increasing problem to red raspberry growers in the Pacific Northwest. There are few chemical insecticides registered on raspberries which will give good control of adults and virtually none that can be used to control the larvae. Entomogenous nematodes have not worked well for several people who have tested them on raspberries or strawberries. Better control methods are needed for these pests.

OBJECTIVES:

1. Test biological and chemical agents for efficacy against root weevils.
2. Provide services and data to the manufacturers and IR-4 Program for registration of efficacious materials.

PROPOSED RESEARCH:

The materials tested will include any chemical and biological agents that are available. Examples of the former are Margosan-O (extract from neem seed) and pyrethroid chemicals. The latter includes items such as entomopathogenic fungi, one of which we believe will be available for testing in 1992.

Most materials will be aimed at adult weevils to prevent egg laying. They will be tested first in the laboratory, if possible. That procedure involves placing adult weevils on raspberry leaves that have been treated with the candidate material and

observing the weevils for mortality. Promising materials will be tested on raspberries or strawberries in replicated field plots. The results obtained on one of these crops usually will apply to the other crop also.

Materials to be tested for control of larvae in the soil will usually be tested in replicated field trials. Candidate materials must have the ability to move downward into the root zone with water but must not be a threat to ground water. Applications usually will be made in the fall and evaluated in the following spring by comparing numbers of larvae in treated and untreated plots.

If a material is worthy of registration on raspberries, we will cooperate with the manufacturer and IR-4 Program in obtaining registration. Such work will include providing efficacy information and treated raspberries for residue studies.

DURATION OF BASE PROJECT:

March 1, 1991 - February 28, 1994.

BUDGET:

		1991-92
01	Temporary worker	$ 3,000
03	Material & services	340
04	Travel	500
07	Employee benefits (8% of 01)	160
	Total	$ 4,000

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