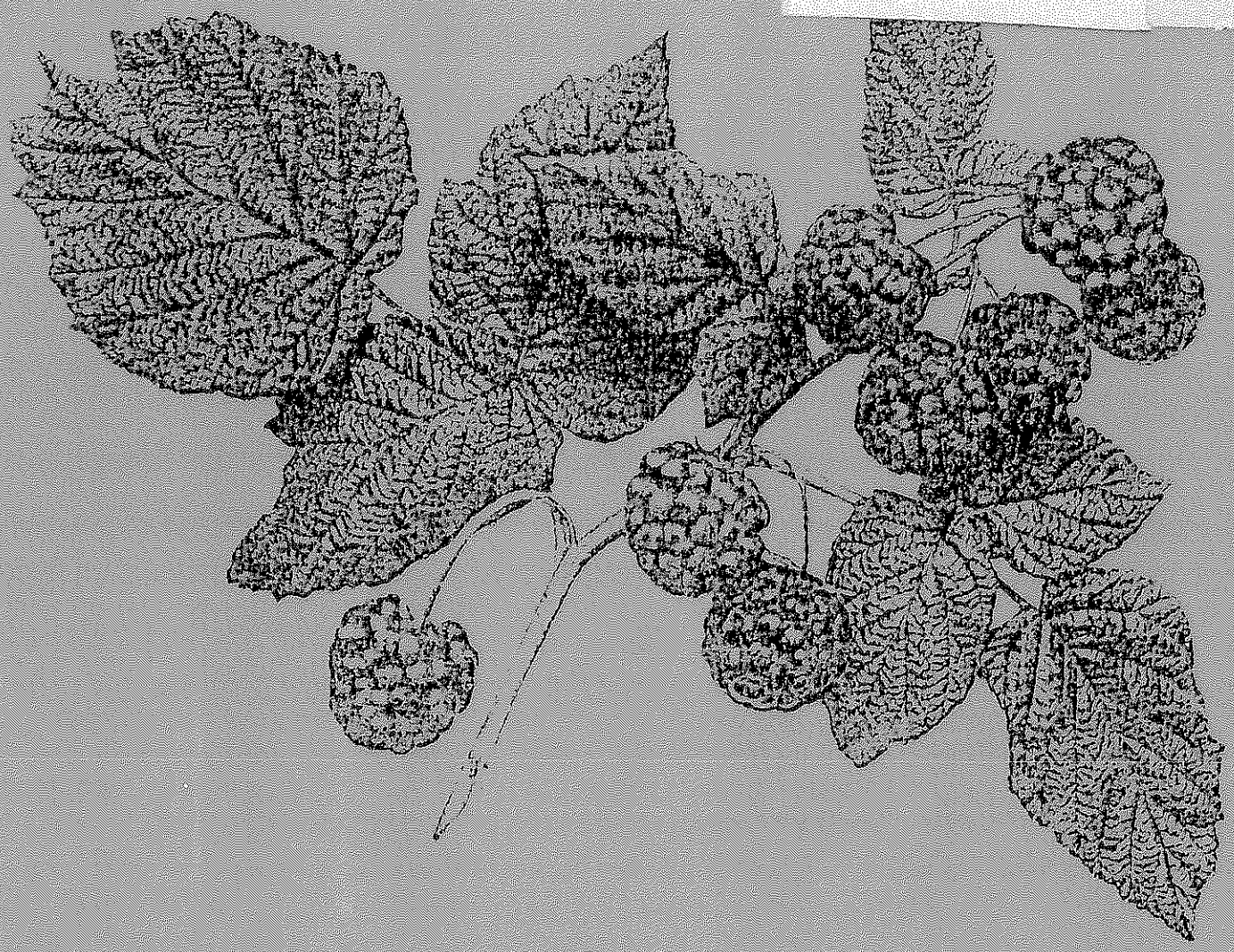

1991
RED RASPBERRY RESEARCH PROPOSALS

1990 PROGRESS REPORTS

to the

WASHINGTON STATE RED RASPBERRY COMMISSION

and

NORTHWEST RED RASPBERRY GROWERS ASSOCIATION

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1990-91

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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	$20,500
13C-3755-8640	Advanced Testing	Moore	3,150
13C-3755-4640	Machine Harvesting	Moore	1,100
13C-3755-3775	Cold Hardiness	Hummel	3,742
13C-3761-1741	Ground Water Contamination	Bristow	1,650
13C-3761-2763	React. to Ridomil	Bristow	600
13C-3761-1783	Captan (Final Report)	Bristow	-0-
13C-3543-2857	Overwintering - Mites	Shanks	9,350
13C-3555-2783	Caneburning	Cameron	7,800
13C-3555-5783	Leaf/Fruit Ratio	Cameron	3,600
13C-3555-5956	Micropropagation	Cameron	3,500
13C-3555-4883	Mite Feeding - Physiology	Cameron	2,260
13L-3419-4840	BMP Manual	Howard	-0-
13L-3419-3840	Living Mulches	Howard	-0-
- - -	Bushy Dwarf Virus	Martin	5,500
- - -	Tomato Ringspot Virus	Rochon	5,000
58091 HS-8-114	Virus Testing Cultivars	Volk	4,500
		SUB-TOTAL	$72,252
NEW PROJECTS			
	Evaluation of Margosan-O	Stark	$ 1,000
		SUB-TOTAL	$ 1,000
		GRAND TOTAL	$73,252

PROJECT NO.: 13C-3755-5641

TITLE: Red Raspberry Breeding, Genetics and Clone Evaluation

PERSONNEL: Patrick P. Moore, Assistant Horticulturist; Jo Ann Robbins, Horticulture Research Specialist; WSU Puyallup

JUSTIFICATION:

Red raspberry breeding programs in the Pacific Northwest 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 in the 40 years since its release.

New cultivars are needed which are better suited for fresh marketing, the most rapidly growing segment of the industry. In addition, improved resistance to Phytophthora root rot and immunity to raspberry aphid (a vector of several viruses) are needed. Recent research by Agriculture Canada scientists has demonstrated that aphid immunity effectively controls the spread of Raspberry Leafspot Virus, a virus disease found in many Pacific Northwest 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:

Forty five crosses were made in 1990. Twenty eight of the crosses were for main crop raspberries and 18 crosses were for fall bearing raspberries. Aphid

and root rot resistant clones were used in the main crop crosses. Ruby (NY 114) and root rot resistant wild North American red raspberry with good fruit quality were used extensively in the fall bearing raspberry crosses. Seedlings from these crosses will be planted at Puyallup, spring 1991. Seed from seven locations in the Yukon were received and will be grown in root rot infested soil and selected seedlings evaluated for cold hardiness. In 1990, 2,170 seedlings were planted, 1,852 main crop and 318 fall fruiting. All were screened in the greenhouse for resistance to the raspberry aphid prior to planting in the field. Selections will be made among these seedlings in 1992.

Twenty seven selections and cultivars were planted in replicated selection trials for yield and fruit quality evaluations. Six of these were planted in a fall bearing planting which will be managed only for the fall crop. All selections made in 1989 were planted in soil infested with root rot at Puyallup in 1990 to determine levels of susceptibility to disease.

Eighteen new selections were made in 1990. No aphids were observed on 13 of these selections, and they may be aphid resistant. Schonemann, Cherokee, BC 83-16-50 and WSU 892 were the parents most highly represented. One of the selections has large yellow fruit that stores well. These selections will be propagated and grown in selection trials and root rot evaluation plantings at Puyallup in 1991.

The 1988 selection trial was harvested for the first time in 1990. The planting suffered damage from a spring application of Karmex and performance was lower and more variable than expected. The highest yielding selection was WSU 985 (Table 1) with a season similar to Willamette (Table 2) but very soft fruit. The second highest yield was for WSU 991, a yellow fruited selection. It had the largest and firmest fruit, and in 1990 it had a short early season. The third highest yielding was BC 80-28-50, which has been dropped by the BC breeding program. The planting will be harvested again in 1991 and selections re-evaluated without Karmex damage.

The 1987 selection trial was harvested for the second time in 1990. The highest yielding clones for the two year period were Meeker, Comox and Schonemann (Table 3). The next highest yielding were WSU 968 and WSU 967, both aphid resistant selections. WSU 968 is an early season selection and WSU 967 late season (Table 4). Tulameen has had only average yields in both 1989 and 1990, however it had the largest fruit. WSU 968 is the most promising of the WSU selections in this planting.

The 1986 selection trial was harvested for the second time in 1990. The

highest yielding selections were WSU 944 and WSU 942 (Table 5). WSU 944 was mid-season and WSU 942 was late season (Table 6). WSU 942 held up well in fresh market trials and is the most promising of the WSU selections in this planting. Virus free propagation material was maintained at Puyallup. Plants of Pacific Northwest cultivars and advanced selections were distributed to certified plant propagators.

PROPOSED RESEARCH:

WSU 991 will be propagated from field material for limited grower trials in 1991. It is also being micropropagated for further multiplication.

WSU 942 and WSU 968 in the 1986 and 1987 selection trials, respectively, will be evaluated again in 1991.

Crosses in 1991 will again emphasize aphid resistance and root rot resistance. Seedlings from 1990 crosses will be screened for aphid resistance prior to planting at Puyallup and will be available for selection in 1993.

Selections made in 1990 will be planted along with standard cultivars in replicated yield trials and root rot evaluation plantings at Puyallup. Selections will be made among the seedlings planted in 1989. Selections in the 1988 and 1989 selection trials will be harvested for yield, fruit weight, firmness, preharvest fruit rot and season of harvest. Fruit will be evaluated for fresh market and/or processing quality.

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 1991, project being revised.

DURATION OF THIS PROPOSAL: First of three years.

BUDGET:

	1990-91	1991-92
00 Salary	$ 7,719 (.4 FTE)	$ 8,554 (.4 FTE)
01 Wages	4,000	5,000
03 Supplies and Services	3,775	4,172
04 Travel	300	300
07 Benefits	2,206	2,474
Total	$18,000	$20,500

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

	Yield (T/A)	Fruit rot (%)	Fruit weight (g)	Firmness (g)
WSU 985	5.9	0.8 c-d	3.8 a-b	137 c-e
WSU 991	5.6	3.6 a	4.1 a	244 a
BC 80-28-50	5.5	0.6 d	2.9 b-c	173 b-d
WSU 988	5.5	0.7 d	3.3 a-c	158 b-d
WSU 979	5.3	0.2 d	2.8 b-c	192 a-c
WSU 983	5.3	1.1 c-d	3.0 b-c	192 a-c
WSU 982	5.3	0.8 c-d	2.9 b-c	244 a
Meeker	5.1	0.7 d	2.6 c-d	199 a-b
WSU 984	4.9	2.1 b	3.4 a-c	211 a-b
Chilcotin	4.2	0.6 d	2.9 b-c	189 a-c
WSU 940	4.1	0.6 d	2.9 b-c	190 a-c
Centennial	4.1	1.6 b-c	3.1 a-c	192 a-c
Goldenwest	3.9	0.4 d	1.7 d	93 e
WSU 989	3.6	0.5 d	2.6 c-d	132 d-e
Willamette	3.2	0.7 d	2.3 c-d	167 b-d
Average	4.8	1.0	3.0	181

Means of three replications of three hills.

Table 2. 1990 harvest season of 1988 planted raspberries at Puyallup, WA.

	Date			Length of season (days)
	5% Harvest	50% Harvest	95% Harvest	
Willamette	6/20 g	7/2 h	7/13 h	23 f
WSU 985	6/21 f-g	7/4 g	7/18 f-g	27 b-f
WSU 983	6/21 f-g	7/3 g-h	7/16 g-h	25 e-f
WSU 991	6/21 f-g	7/4 f-g	7/16 g-h	25 d-f
WSU 988	6/21 f-g	7/6 e-f	7/21 e-f	30 a-d
WSU 989	6/22 e-g	7/9 c-d	7/23 d-e	31 a-c
Chilcotin	6/23 e-g	7/9 c-d	7/26 b-d	33 a
WSU 979	6/24 d-f	7/11 b-c	7/25 c-e	31 a-c
WSU 982	6/25 c-e	7/8 d-e	7/23 d-e	28 a-e
WSU 940	6/26 b-d	7/10 c-d	7/26 b-d	30 a-e
BC 80-28-50	6/27 b-c	7/12 b	7/30 a-b	33 a
WSU 984	6/27 b-c	7/12 b	7/26 b-d	29 a-e
Centennial	6/29 a-b	7/16 a	8/1 a	32 a-b
Meeker	7/1 a	7/16 a	7/28 a-c	27 c-f
Goldenwest	7/2 a	7/16 a	7/29 a-c	27 c-f
Average	6/25	7/9	7/23	29

Table 3. 1989-1990 harvests of 1987 planted raspberries at Puyallup, WA.

	Yield (T/A)			Fruit rot (%)	Fruit weight (g)	Firmness (g)
	1989	1990	Total			
Meeker	9.3	9.2 a-b	18.5	0.8 b	3.3 c-d	249 c
Comox	7.2	9.7 a	16.9	1.2 b	3.7 a-b	304 a-b
Schonemann	8.2	8.5 a-c	16.7	1.2 b	3.3 c-d	191 d
WSU 968	6.9	8.8 a-b	15.7	1.1 b	3.5 b-d	277 a-c
WSU 967	7.5	7.1 b-e	14.6	2.6 a	3.5 b-c	316 a
WSU 965	8.1	6.3 c-e	14.4	3.4 a	3.2 d	273 a-c
Tulameen*	6.6	7.3	13.9	0.3	4.3	210
WSU 974	4.9	7.9 a-d	12.8	0.7 b	3.9 a	309 a-b
Chilliwack	6.6	5.2 e	11.8	0.8 b	3.2 d	271 b-c
Willamette	5.6	5.2 e	10.8	0.9 b	2.8 e	172 d
WSU 966	3.2	7.5 a-e	10.7	1.2 b	2.5 e	294 a-b
WSU 975	3.7	5.9 d-e	9.6	0.4 b	2.8 e	242 c
WSU 960*	4.0	4.7	8.7	1.1	3.8	251
Average	6.3	7.2	13.5	1.2	3.3	258

Means of three replications of three hills.
* Only present in two replications, data omitted from statistical analysis.

Table 4. 1990 harvest season for 1987 planted raspberries at Puyallup, WA.

	Date			Length of season (days)
	5% Harvest	50% Harvest	95% Harvest	
WSU 975	6/24 e	7/10 d-e	7/25 c-d	30.7 a
Willamette	6/26 d-e	7/6 f	7/22 e	25.7 b
WSU 968	6/27 c-e	7/9 e-f	7/24 d-e	26.3 b
WSU 960	6/28 c-d	7/11 d-e	7/24 d-e	26.5 b
WSU 974	6/28 c-d	7/12 d	7/25 c-d	27.0 b
Tulameen	6/30 b-c	7/11 d-e	7/25 c-d	25.5 b
Chilliwack	6/30 b-c	7/11 d-e	7/24 d-e	24.3 b
Comox	6/30 b-c	7/13 d	7/27 c	27.0 b
WSU 967	6/30 b-c	7/16 d	8/2 b	33.0 a
Schonemann	7/2 b	7/13 d	7/27 c	25.7 b
Meeker	7/7 a	7/18 b-c	7/31 b	24.3 b
WSU 966	7/7 a	7/23 a	8/9 a	33.0 a
WSU 965	7/8 a	7/20 b	8/2 b	24.7 b
Average	6/30	7/13	7/28	27.2

Table 5. 1989-1990 harvests of 1986 planted raspberries at Puyallup, WA.

	Yield (T/A)			Fruit rot (%)	Fruit weight (g)	Firmness (g)
	1989	1990	Total			
WSU 944	8.0	9.5	17.5	2.5	3.6	265 a-e
WSU 942	7.6	9.3	16.9	1.0	3.7	311 a-c
WSU 959	9.8	5.9	15.7	1.8	3.4	210 d-f
Meeker*	6.1	9.3	15.4	0.8	3.2	235
WSU 941	7.1	7.4	14.5	0.7	3.3	295 a-d
WSU 957	4.5	9.3	13.8	2.0	3.7	255 b-e
WSU 953	6.9	6.8	13.8	1.7	3.6	305 a-c
WSU 948	7.9	5.5	13.4	1.3	3.4	206 e-f
WSU 946	6.6	6.3	13.0	2.6	4.0	255 b-e
Comox	6.0	6.8	12.8	1.1	3.4	241 b-e
Chilcotin	4.7	8.1	12.8	1.0	3.2	212 d-f
WSU 958	5.5	7.2	12.7	1.3	4.2	315 a-c
Chilliwack	5.4	6.9	12.2	0.6	3.2	256 a-e
Skeena	6.4	5.6	12.0	0.7	2.8	149 f
WSU 937	5.6	6.0	11.6	0.8	3.1	282 a-e
WSU 951	4.9	6.2	11.1	1.8	3.7	226 c-f
WSU 954	5.2	5.5	10.7	1.3	3.2	329 a-b
WSU 956	6.5	3.6	10.1	1.4	4.1	303 a-c
Willamette	5.4	4.7	10.0	0.6	3.2	208 d-f
WSU 737	4.2	5.2	9.3	1.1	3.3	267 a-e
WSU 952	3.9	5.0	9.0	5.2	3.7	345 a
WSU 949	5.0	3.0	7.9	2.8	3.2	281 a-e
Average	6.1	6.5	12.6	1.6	3.5	261

Mean of two four hill plots.
*Based on one four hill plot, data omitted from statistical analysis.

Table 6. 1990 harvest season for 1986 planted raspberries at Puyallup, WA.

	Date			Length of season (days)
	5% Harvest	50% Harvest	95% Harvest	
Skeena	6/22 g	7/3 h	7/18 g-h	26.5
WSU 946	6/25 f-g	7/4 g-h	7/17 h	21.5
WSU 957	6/25 f-g	7/9 f-g	7/25 d-g	30.0
Chilcotin	6/26 f-g	7/9 f-g	7/26 d-f	30.0
Comox	6/26 f-g	7/8 f-g	7/22 f-h	26.0
WSU 959	6/26 f-g	7/11 d-f	7/27 c-f	30.5
WSU 944	6/27 f-g	7/11 d-f	7/29 b-f	32.0
WSU 958	6/27 e-g	7/8 f-g	7/24 e-g	26.5
Willamette	6/28 e-g	7/6 f-h	7/22 f-h	24.0
Chilliwack	6/28 e-g	7/10 e-f	7/24 e-g	25.5
WSU 937	6/29 d-g	7/9 f-g	7/25 e-g	26.0
WSU 948	6/29 c-f	7/8 f-g	7/24 e-g	24.5
WSU 951	6/29 c-f	7/9 f-g	7/22 f-h	23.0
WSU 949	7/2 b-f	7/15 c-d	7/28 b-f	25.5
WSU 956	7/2 b-f	7/15 c-e	7/30 a-e	28.0
WSU 941	7/4 a-e	7/20 a-c	8/3 a-c	29.5
WSU 954	7/6 a-d	7/21 a-b	8/4 a-b	29.0
WSU 737	7/6 a-c	7/17 b-c	7/30 b-e	23.5
Meeker	7/7 a-b	7/18 b-c	7/30 b-e	23.0
WSU 952	7/7 a-b	7/19 a-c	8/1 a-d	25.5
WSU 942	7/9 a-b	7/20 a-c	8/3 a-c	24.5
WSU 953	7/11 a	7/24 a	8/6 a	25.5
Average	6/30	7/12	7/27	26.4

PROJECT NO.: 13C-3755-8640

TITLE: Advanced Testing of Washington State University Raspberry Selections

PERSONNEL: Patrick P. Moore, Assistant Horticulturist, WSU REC Puyallup
Robert A. Norton, Horticulturist, WSU NWREC, Mt. Vernon
J. Scott Cameron, Assistant Horticulturist, WSU SWRU, 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 PREC in Puyallup, WSU NWREU in Mt. Vernon, and WSU SWRU in 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 first time in 1990. The highest yielding cultivars were Meeker, Comox, and Chilliwack (Table 1). There were significant clone x location effects indicating that not all clones respond in the same way to location differences.

The planting at Vancouver did not establish well for unknown reasons. At Vancouver, Chilliwack was the highest yielding (Table 2) followed by Chilcotin. WSU 805 was early and WSU 908 was very late. Fruit size was small for all clones, but WSU 908 and Chilcotin were the largest.

The planting at Puyallup was damaged by a spring application of Karmex and was more variable and less productive than expected. Meeker, Comox, WSU 781, and Chilliwack were the highest yielding although there were no significant differences among clones for yield (Table 3). WSU 892 was the earliest ripening and WSU 908 the latest. WSU 908 was the firmest followed by Chilliwack, WSU 892, Comox, and WSU 805. Firmness was measured only on the Puyallup planting.

Mt. Vernon had the best establishment of the three locations. Meeker was the highest yielding followed by Comox and WSU 781 (Table 4). Willamette and WSU 892 were the earliest ripening and WSU 908 was the latest. WSU 908 had the largest fruit.

Due to difficulties at each location, strong conclusions based on the 1990 harvest results are not possible. Plants at all locations are growing well at this time and more representative results should be obtained in 1991.

PROPOSED RESEARCH:

In 1991, the advanced selection plantings will be harvested at all three locations. Total yield, fruit rot, fruit weight, and midpoint of harvest will be obtained at all three locations.

WSU 991, a very promising yellow-fruited selection, will be propagated from field material and distributed to commercial growers. It will also be distributed for regional trials in the Pacific Northwest. WSU 991 is currently being micropropagated for more extensive propagation in the future.

TERMINAL DATE OF PROPOSAL: Two of two years.

BUDGET:

	1990-91	1991-92
01 Wages	$2,250	$2,700
03 Goods and Services	337	315
07 Benefits	113	135
Total	$2,700	$3,150

Amount to be divided among the three project leaders.

Table 1. 1990 harvest of 1988 planted raspberries at Mt. Vernon, Puyallup, and Vancouver, WA.

Clone	Yield (T/A)	Fruit rot (%)	Fruit weight (g)	Midpoint of harvest
Meeker	7.4	0.6	3.3	7/11
Comox	6.9	1.1	3.5	7/8
Chilliwack	6.7	0.7	3.3	7/10
Chilcotin	5.3	1.2	3.4	7/7
WSU 781	5.2	1.0	2.9	7/6
WSU 805	4.5	1.2	3.1	7/3
Willamette	4.5	0.9	2.8	7/1
WSU 892	4.4	1.5	3.3	7/4
WSU 908	3.4	0.9	3.6	7/16
Average	5.4	1.0	3.3	7/7

Three replications of three hills at each location.
Significant clone x location effects for all characters.

Table 2. 1990 harvest of 1988 planted raspberries at Vancouver, WA.

Clone	Yield (T/A)	Fruit rot (%)	Fruit weight (g)	Midpoint of harvest
Chilliwack	7.3 a	0.0 a	3.0 a	7/10 ab
Chilcotin	5.4 ab	0.4 a	3.3 a	7/1 de
Meeker	4.4 bc	0.0 a	3.0 a	7/7 bc
Comox	4.3 bc	0.1 a	3.1 a	7/3 cd
WSU 908	3.2 b-d	0.0 a	3.3 a	7/15 a
WSU 805	3.0 b-d	0.5 a	3.0 ab	6/27 ef
Willamette	2.9 cd	0.1 a	2.5 c	6/25 f
WSU 892	2.8 cd	0.3 a	3.1 a	7/3 cd
WSU 781	1.7 d	0.1 a	2.6 bc	6/30 de
Average	3.9	0.2	3.0	7/3

Means based on three replications of three hills.

Table 3. 1990 harvest of 1988 planted raspberries at Puyallup, WA.

Clone	Yield (T/A)	Fruit rot (%)	Fruit weight (g)	Fruit firmness (g)	Midpoint of harvest
Meeker	5.8	0.4	3.0 bc	219 bc	7/14 b
Comox	5.7	1.3	3.5 a	237 b	7/9 c
WSU 781	5.5	0.8	2.7 bc	152 d	7/6 cd
Chilliwack	5.4	0.6	3.0 bc	249 b	7/9 c
WSU 805	5.0	1.1	3.0 bc	222 bc	7/6 cd
Chilcotin	4.6	0.2	3.1 ab	189 c	7/7 cd
WSU 892	3.7	0.9	2.8 bc	248 b	7/1 e
Willamette	3.7	1.0	2.7 c	157 d	7/3 de
WSU 908	3.2	0.7	2.8 bc	288 a	7/18 a
Average	4.7	0.8	2.9	218	7/8

Means based on three replications of three hills.

Table 4. 1990 harvest of 1988 planted raspberries at Mt. Vernon, WA.

Clone	Yield (T/A)	Fruit rot (%)	Fruit weight (g)	Midpoint of harvest
Meeker	12.1 a	1.3 b	4.0 bc	7/11 bc
Comox	10.7 ab	2.0 ab	3.9 bc	7/13 b
WSU 781	8.3 bc	2.2 ab	3.3 cd	7/12 bc
Chilliwack	7.2 c	1.5 b	3.9 bc	7/12 b
Willamette	6.8 cd	1.5 b	3.2 d	7/7 d
WSU 892	6.6 cd	3.2 a	4.2 ab	7/8 d
Chilcotin	5.9 cd	3.0 a	3.8 b-d	7/13 b
WSU 805	5.9 cd	2.3 ab	3.5 b-d	7/10 c
WSU 908	3.8 d	2.0 ab	4.7 a	7/15 a
Average	7.5	2.1	3.8	7/11

Means based on three replications of three hills.

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.

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:

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

BUDGET:

	1989-90	1990-91	1991-92
01 Wages	$ 0	$ 0	$ 350
03 Goods and Services	140	0	600
04 Travel	60	0	132
07 Benefits	0	0	18
Total	$200	$ 0	$1,100

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 plant age 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 plant age on cold hardiness of 3 standard red raspberry cultivars.

3. To continue to evaluate the potential of differential thermal analysis as an alternative to the visual browning method for determining red raspberry cold hardiness.

PROGRESS:

Cold hardiness of stems and buds of 10 named cultivars ('Algonquin', 'Centennial', 'Chilcotin', 'Chilliwack', 'Comox', 'Haida', 'Meeker', 'Skeena', 'Tulameen', 'Willamette') and 3 numbered selections (BC80-28-50, WSU608 and WSU892) was tested on November 15, 1989, January 25 and March 13, 1990. 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, tissue injury was determined by the visual browning method and a Tk_{50} (temperature at which 50% damage occurred) for the buds and stem of each cane section was calculated from the visual browning data.

Results of the November 15, 1989, January, 25 and March 13, 1990 freezing tests are shown in Tables 1, 2 and 3, respectively. In the 1989-1990 freezing tests, some cultivars like 'Chilliwack', 'Haida', and WSU608 which cold acclimated the earliest in the fall (Table 1) deacclimated the most rapidly in the spring (Table 3). The reverse was true for other cultivars like 'Willamette' and 'Meeker': they acclimated more slowly but also retained their bud hardiness later in the spring. This difference in deacclimation was also observed in the amount of bud development prior to the March 13 freeze. In general, the least hardy cultivars on March 13, 1990 had buds that were showing visible leaves while buds of the hardiest cultivars were only starting to elongate. Although this relationship of rapid acclimation-rapid deacclimation versus slow acclimation-slow deacclimation did not hold true for all cultivars, a similar pattern was observed for 'Willamette', 'Meeker', and 'Chilliwack' during the 1988-1989 winter (Hummel and Moore, 1990, Proc. W. Wash. Hort. Assoc. 80:110-112). Because it was one of the hardier cultivars on all 3 freezing test dates (Tables 1, 2 and 3), WSU892 may have promise as a selection that, while acclimating quite early in the fall, retains its hardiness later in the spring.

A preliminary experiment was conducted to determine the potential of differential thermal analysis (DTA), for measuring the hardiness levels of red raspberry. Samples from 'Chilcotin' and 'Willamette' canes collected February 13, 1990, were frozen for visual browning analysis in the laboratory at Puyallup at the same time as samples from these canes were frozen using DTA at Dr. Del Ketchie's laboratory at the Tree Fruit Research and Extension Center in Wenatchee. Primary buds containing both vegetative and reproductive primordia were used for DTA.

Results of this preliminary DTA experiment showed exotherms (an indication that water is freezing) were produced in the buds at temperatures below the free water exotherms. The relationship of these exotherms to tissues within the bud and to the actual killing point of the bud is not clear. For

example, an exotherm was detected in the 'Chilcotin' bud at about -27°C. Results of the visual browning test indicated the Tk_{50} of 'Chilcotin' buds was -22°C and all buds were dead by -24°C. However, as observed in the 1988-1989 freezing tests (Hummel and Moore, 1990, Proc. W. Wash. Hort. Assoc. 80:110-112), bud break and some enlargement of the leaf blade occurred even though the cambium and vascular tissue in the base of the bud were dead. In the February 13 freeze test, leaf blade tissue of some buds was alive and expanding even at -28°C. The -27°C exotherm was most likely related to freezing of supercooled leaf primordia and not to the functional viability of the bud. Additional tests must be conducted to determine whether or not the lethal exotherm(s) for bud viability can be distinguished in red raspberry buds.

PROPOSED RESEARCH:

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 1990-1991 winter.

There is some evidence from grower fields that the age of the planting influences red raspberry cold hardiness. An experiment will be conducted to determine if a plant age effect can be detected in laboratory freezing tests. Plantings of 'Meeker', 'Willamette', and 'Chilcotin' established in 1988, 1989 and 1990 at Farm 5 near Puyallup will provide the test material.

Additional DTA testing will be done to determine whether or not it is a feasible method of cold hardiness determination in red raspberry buds.

TERMINAL DATES OF PAST PROJECTS: June 30, 1993 and June 30, 1991

DURATION OF THIS PROJECT: 3/3 Third year of a three-year proposal

BUDGET:

	Current **1990**	Proposed **1991**
00 Salaries	$2,790	$2,930
03 Supplies and Services	50	50
07 Benefits	725	762
TOTAL	$3,565	$3,742

Table 1. Cold hardiness of red raspberry cultivars collected from the field November 15, 1989.

Cultivar	Tk_{50} (°C)[z] Bud	Stem
Centennial	-16.1 a[y]	-16.1 a
Meeker	-16.4 ab	-17.2 ab
Tulameen	-16.6 abc	-17.2 ab
Willamette	-16.7 abc	-17.0 ab
Comox	-17.0 abcd	-19.1 cd
Skeena	-17.9 bcde	-18.3 bc
Algonquin	-18.3 cdef	-19.7 cd
Chilcotin	-18.6 def	-19.0 cd
BC80-28-50	-18.7 def	-19.5 cd
WSU 892	-18.8 ef	-19.8 d
Chilliwack	-19.0 ef	-19.5 cd
WSU 608	-19.8 fg	-21.7 e
Haida	-21.1 g	-21.7 e
$LSD_{0.05}$	1.7	1.4

[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 Fisher's least significant difference (LSD) test.

Table 2. Cold hardiness of red raspberry cultivars collected from the field January 23, 1990.

Cultivar	Tk_{50} (°C)[z] Bud	Stem
Willamette	-17.3 a[y]	-17.7 a
Algonquin	-19.2 b	-20.0 b
Tulameen	-20.7 bc	-22.6 cde
Centennial	-21.6 cd	-22.1 cd
Skeena	-22.0 cd	-21.7 c
Haida	-22.1 cd	-23.7 ef
BC80-28-50	-22.2 cd	-23.7 ef
Meeker	-22.2 cd	-23.0 cdef
WSU 608	-22.6 d	-23.3 def
WSU 892	-22.7 d	-23.7 ef
Comox	-22.8 d	-24.3 f
Chilliwack	-22.8 d	-23.9 ef
Chilcotin	-22.8 d	-23.5 def
$LSD_{0.05}$	1.7	1.6

[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 Fisher's least significant difference (LSD) test.

Table 3. Cold hardiness of red raspberry cultivars collected from the field March 13, 1990.

Cultivar	Tk_{50} (°C)[z] Bud	Stem
Chilliwack	- 8.2 a[y]	-15.5 b
Haida	- 9.2 ab	-16.7 bc
WSU 608	-11.0 b	-17.7 bcd
Tulameen	-11.1 b	-16.5 bc
Algonquin	-11.8 bc	-12.8 a
BC80-28-50	-14.4 cd	-17.6 bc
Centennial	-15.6 de	-17.2 bc
Chilcotin	-16.0 de	-19.8 de
Comox	-16.0 de	-20.0 e
Skeena	-16.3 de	-18.0 cde
WSU 892	-16.6 de	-18.5 cde
Meeker	-16.7 de	-19.8 de
Willamette	-17.8 e	-18.7 cde
$LSD_{0.05}$	2.8	2.2

[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 Fisher's least significant difference (LSD) test.

PROJECT NO.: 13C-3761-2741

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

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 strawberries and red raspberries 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 strawberries 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 strawberries are well drained and often coarse textured, both of which increase the risk of pesticide movement.

4. Strawberries 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 strawberries 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. Very low levels (less than 10 ppb) of metalaxyl, metalaxyl acid, carbofuran and simazine were detected in the winter 86/87 (Tables 2 and 3). During subsequent winters, only metalaxyl acid and simazine were found. The disappearance of carbofuran from groundwater in later years most likely reflects enhanced biological degradation.

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 acid, carbofuran and simazine were detected in the winters 86/87 and 87/88; while only metalaxyl acid and simazine were detected in winters since then. Few if any residues were detected during the summer months.

Of the three test pesticides, metalaxyl is the most water soluble (7100 ppm); yet, simazine, with the lowest solubility (~2 ppm), was the one most commonly found in ground water. The two breakdown products of carbofuran were not detected in ground water at either site.

PROPOSED RESEARCH:

In 1986 a large field study was initiated to measure the dissipation and downwater movement of carbofuran (Furadan), metalaxyl (Ridomil) and simazine (Princep) following their application to alluvial soils in western Washington. The three pesticides have been applied to red raspberry and strawberry plantings at two test sites. Commercial rates and timings were used. This is a five year project with pesticides being applied in each of the first 3 years. No pesticides will be applied in the last 2 years, but the movement and fate of pesticides applied earlier will be followed.

Water samples are collected monthly from 13 groundwater monitoring wells permanently installed in the raspberry plantings. Water samples are analyzed for residues of the test pesticides plus 3 breakdown products (Table 1). The residue work is performed on a contract basis by the Department of Agricultural Chemistry at Oregon State University for $20.00 per sample. The total cost for samples to be collected between December 1990 and June 1991 (the end of the 5-year sampling period) will be $3,300.00. This proposal requests funds

to cover one-half of the cost. An identical proposal is being submitted to the Washington Strawberry Commission.

TERMINATION DATE OF THE BASE PROJECT:

Project No. 0741, December 31, 1990 (currently undergoing revision).

PROJECT DURATION: 1 year

BUDGET:

	Proposed 1990-91
03 Goods and Services	$1,650.00
Total	$1,650.00

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
Herbicide	Simazine (Princep)	

[z] Common name (trade name)

Table 2a. Residues of test pesticides and breakdown products in groundwater[z] (Site F).

	Concentration, ppb[y]															
	1986				1987											
	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Shallow wells (1-2 m)																
Metalaxyl						0.1	0.1	-[x]								
Metalaxyl acid						0.3	2.7	<0.3								
Carbofuran						1.9	2.8	-								
3-hydroxycarbofuran						-	-	-								
3-ketocarbofuran						-	-	-								
Simazine						3.8	2.5	<0.1								
Deep wells (3-4 m)																
Metalaxyl	-	-	-	-	-	-	-	Tr	-	-	-	-	-	-	<0.5	<0.5
Metalaxyl acid	-	-	-	-	-	<0.2	<0.1	-	-	-	-	-	-	-	<0.5	<0.5
Carbofuran	-	-	-	-	-	-	-	-	0.1	<0.1	-	-	-	-	<0.2	<0.2
3-Hydroxycarbofuran	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-ketocarbofuran	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Simazine	-	-	-	-	Tr	<0.1	0.1	0.1	0.8	-	-	<0.1	<0.1	-	<0.1	<0.1

[z] Data for raspberries and strawberries combined.

[y] ppb = parts per billion (micrograms per liter). (Data not corrected for recovery; recovery >70% in all cases).

[x] - = not detected.

Table 2b. Residues of test pesticides and breakdown products in Groundwater[z] (Site F).

	Concentration, ppb[y]																							
	1988												1989											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Shallow wells (1-2 m)																								
Metalaxyl				-[x]									-		-	-								
Metalaxyl acid				3.0									1.3		15.2	-								
Carbofuran				-									-		-	-								
3-hydroxycarbofuran				-									-		-	-								
3-ketocarbofuran				-									-		-	-								
Simazine				1.1									1.0		0.6	0.6								
Deep wells (3-4 m)																								
Metalaxyl	<0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metalaxyl acid	<0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	1.3	0.3	0.3	1.0	0.2	<0.1	-
Carbofuran	<0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-hydroxycarbofuran	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-ketocarbofuran	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Simazine	<0.2	-	-	-	-	-	-	-	-	-	-	-	<0.1	<0.1	<0.1	0.3	0.1	-	-	-	-	-	-	<0.1

[z] Data for raspberries and strawberries combined.

[y] ppb = parts per billion (microgram per liter) (Data not corrected for recovery; recovery >70% in all cases.

[x] - = not detected.

Table 3a. Residues of test pesticides and breakdown products in groundwater[z] (Site P).

	Concentration, ppb[y]															
	1986				1987											
	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Shallow wells (1-2 m)																
Metalaxyl			-			-	-									
Metalaxyl acid			-[x]			0.6	0.3									
Carbofuran			-			0.6	1.9									
3-hydroxycarbofuran			-			-	-									
3-ketocarbofuran			-			-	-									
Simazine			-			<0.1	<0.1									
Deep wells (3-4 m)																
Metalaxyl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.7	<0.5
Metalaxyl acid	-	-	-	-	-	0.2	<0.1	<0.1	<0.1	-	-	-	-	-	<0.5	<0.5
Carbofuran	-	-	-	-	-	0.2	0.1	<0.1	-	-	-	-	-	-	<0.2	0.6
3-hydroxycarbofuran	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-ketocarbofuran	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Simazine	-	-	-	-	-	<0.1	<0.1	<0.1	<0.1	-	-	-	<0.1	-	0.9	<0.1

[z] Data for raspberries and strawberries combined.

[y] ppb = parts per billion (microgram per liter) (Data not corrected for recovery; recovery >70% in all cases.

[x] - = not detected.

Table 3b. Residues of test pesticides and breakdown products in groundwater[z] (Site P).

	Concentration, ppb[y]																							
	1988												1989											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Shallow wells (1-2 m)																								
Metalaxyl	-[x]			-									-		-	-								-
Metalaxyl acid	-			5.3									1.9		8.4	4.0								2.1
Carbofuran	0.5			0.4									-		-	-								-
3-hydroxycarbofuran	-			-									-		-	-								-
3-ketocarbofuran	-			-									-		-	-								-
Simazine	-			-									-		-	<0.1								-
Deep Wells (3-4 m)																								
Metalaxyl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metalaxyl acid	-	-	-	6.3	-	-	-	-	-	-	-	0.9	0.5	0.3	7.2	3.5	1.4	0.8	0.4	0.3	0.5	0.2	0.3	1.9
Carbofuran	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-hydroxycarbofuran	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3-ketocarbofuran	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Simazine	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-

[z] Data for raspberries and strawberries combined.

[y] ppb = parts per billion (microgram per liter) (Data not corrected for recovery; recovery >70% in all cases.

[x] - = not detected.

PROJECT DURATION: 2/4

BUDGET:

	Proposed 1990-91
Wages (Timeslip)	$190.00
Employee benefits	10.00
Supplies and services	400.00
TOTAL	$600.00

TERMINATION DATE OF BASE PROJECT:

Project 0640 June 30, 1991

Table 1. Cultivars or selections and resistance to Phytophthora root rot.

Cultivar or selection	Root rot reaction
Cherokee	R
Chilliwack	I
Comox	S
Meeker	I
Newburgh	R
Willamette	S
BC 8028-50	S
BC 8028-53 (Tulameen)	I (?)
WSU 892	R (?)
WSU 1001	R
WSU 1002	R
WSU 1007	R

R = resistant; I = intermediate; S = susceptible.

PROJECT NO.: 13C-3761-1783 (Final Report)

TITLE: Captan on Red Raspberries: Efficacy and Residues

PERSONNEL: Peter R. Bristow, Associate Plant Pathologist
Gwenyth E. Windom, Agricultural Research Technologist III
WSU Puyallup Research and Extension Center

JUSTIFICATION:

The fungicide Captan is widely used by Pacific Northwest raspberry growers to control fungal fruit rots including gray mold (*Botrytis cinerea*). Because Captan has a multi-site mode of action, its continued use is critical in managing resistance to dicarboximide (Ronilan, Rovral) and benzimidazole (Benlate) fungicides.

Captan is currently undergoing special review by the U.S. Environmental Protection Agency. The use of Captan on caneberries will be suspended in early 1990 and it will not be re-registered until acceptable residue and, possibly, efficacy data are generated.

Projects to obtain the necessary data have been submitted to the IR-4 program for funding in 1990. IR-4 gives this project its highest priority rating; however, it will be several months before the outcome of the funding request is known. It is not yet known whether IR-4 will fund both the field studies (efficacy and collection of fruit for residue testing) and the laboratory residue analyses. Often IR-4 programs fund the field study and ask impacted grower groups to finance the residue tests.

Oregon and eastern states growers will likely participate in the field studies. It is hoped they will share with Washington growers in the funding of such a project. Which other states must conduct field studies and the number of residue tests needed is not yet known.

OBJECTIVES:

1. Supply Captan-treated and untreated red raspberries grown in Washington for residue analysis.

2. Evaluate the efficacy of Captan against fruit rots in red raspberries in Washington.

PROGRESS:

The study was conducted with 'Meeker' red raspberries at the WSU Vancouver Research and Extension Unit. Ten applications of Captan were applied to a mature planting between April 10 and July 9, 1990 at approximately 10-day intervals. The plots were mechanically harvested at 0 and 7 days after the final application (0 and 7 days PHI).

Samples of harvest fruit from three separate areas of each treatment at each harvest were shipped frozen to the IR-4 residue laboratory in New York for analysis.

There was little if any fruit rot in the field at either harvest. This probably explains why the Captan treatments did not significantly increase yields (Table 1).

Captan reduced the incidence of fruit rot in post-harvest tests by more than 95% (Table 2). However, in fresh market tests where underripe berries were held for 6 days after being hand picked, Captan controlled fruit rot by 86 and 30% for the first (0 day PHI) and second (7 days PHI) harvests (Table 3).

Ten applications of Captan had no adverse impact on lateral length, number of flowers per lateral, flower abortion, fruit size and rate of ripening. Also, the fungicide did not alter color development in the fresh market tests.

BUDGET STATEMENT:

Two changes in the protocol received from the IR-4 program increased the costs of field portion of this study: i) ten applications were called for instead of the anticipated 3 or 4, and ii) a second rate of Captan was added to the study. These changes markedly increased the number of trips to Vancouver, the number of samples collected, and the amount of frozen fruit shipped (by overnight air freight) to the residue laboratory.

On the plus side, the IR-4 program is fully funding the residue analysis portion of the project. Because of this, surplus funds are being returned to the Commission for reallocation as shown below.

Item	Budgeted	Expended
Field trial	1000.00	2596.03
Residue analysis	2880.00	1283.97*
Total	3880.00	3880.00

* Amount to be returned.

DURATION OF BASE PROJECT:

Project 0668 terminated June 30, 1990.

Table 1. Effect of captan on machine harvested yield.

Treatment	Rate (lb ai/A)	Yield, lbs/plot[z] 1st harvest	2nd harvest	Total
Untreated check	-	6.28 a	8.60 a	14.86 a
Captan	3	6.75 a	7.16 a	13.91 a
Captan	5	6.77 a	8.23 a	15.00 a

[z] Plot = 50 ft of row.

Table 2. Effect of Captan on the incidence of fruit rot in post-harvest rot tests.

Treatment	Rate (lb ai/A)	% fruit rot 1st harvest	2nd harvest
Untreated check	-	43.8 a	37.7 a
Captan	3	0.7 b	1.7 b
Captan	5	1.0 b	0.0 b

Ripe fruit incubated 3 days at 100% relative humidity at 60F.

Table 3. Effect of Captan on the incidence of fruit rot in fresh market tests.

Treatment	Rate (lb ai/A)	% fruit rot 1st harvest	2nd harvest
Untreated check	-	11.3 a	15.3 a
Captan	3	N.T.[z]	10.7 b
Captan	5	1.6 b	10.7 b

[z] N.T. = not tested.

Table 4. Effect of captan on fruit development.

Treatment	Rate (lb ai/A)	Lateral length, in.	Flowers/ lateral no.	Aborted flowers %	Ripe fruit %	Berry size g
Untreated check	-	24.2 a	25.0 a	2.6 a	20.1 a	3.5 a
Captan	3	22.2 a	24.5 a	4.6 a	22.1 a	3.4 a
Captan	5	21.5 a	19.3 a	0.7 a	20.4 a	3.3 a

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 two spotted 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 attract 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.

PROGRESS:

Objective 1. Experimental traps were made from 30-cm squares of burlap sandwiched between two 15-cm squares of pegboard, 30-cm squares of burlap folded into 2.5-cm pleats and tied with twine at the ends and middle, or 36 drinking straws (20-cm x 4 mm diam.) packed into a 20-cm length of 2.5-cm-diam. black PVC pipe. These were placed on the soil within the rows in three raspberry fields on September 15, 1989. Two fields had high numbers of mites during the summer and one had very low numbers. The traps were collected on December 7, 1989. They were washed with a detergent solution to remove arthropods on the burlap or in the straws.

The two arthropods caught in the traps that were of most interest were hibernating twospotted spider mites and adult *Stethorus punctum picipes*. There were surprisingly large numbers of mites caught in the field with low numbers during the growing season. Even larger numbers were caught in the other two fields. The pleated burlap caught the most mites.

Adult *Stethorus* beetles were caught at all three locations. The largest number was caught at one of the high mite population fields. The small number of *Stethorus* beetles found in the field with low numbers of mites reinforces our hypothesis that small numbers of this predator may keep small populations of spider mites from becoming large.

Objective 2. Predator responses to very low early season populations of spider mites were studied by use of trap-colonies of mites. In this method, 5-35 spider mites were placed on individually marked raspberry leaflets in field plantings. The leaflets were removed from the plant 1 week later and examined in the laboratory for the presence of predators. The trap-colony sampling technique proved to be highly effective in capturing adults of the predator *Stethorus*, and demonstrated significant activity by this predator during the early season when spider mite populations are very low. In early May, when 50-leaflet samples from the rest of the field indicated zero mites per leaflet, as many as 50% of the trap colonies became infested by *Stethorus*. We suspect that these early season predator populations and their progeny are capable of maintaining biological control of spider mites if properly managed. A cool summer discouraged spider mite populations in general, so most study sites showed very low spider mite densities throughout the season. However, one field, in which malathion was applied in late June, subsequently showed a rapid decrease in *Stethorus* numbers followed by a rapid increase in spider mites late in the season. These observations are consistent with our hypothesis and, if confirmed by future studies, will lead to recommendations for conserving *Stethorus* populations for the control of spider mites in red raspberries.

Objective 3. This objective is to compare the numbers of overwintering predators with peak spider mite densities in the same five fields during the previous and following seasons. This work is on schedule, but final results are not yet available, since this is the first year of the study.

PROPOSED RESEARCH:

Objective 1 was accomplished in 1990. The procedures described below for Objective 2 and 3 are the same as for the previous year. It is necessary to conduct these experiments for 2-3 years in order to know that the results are repeatable and thus to be able to draw conclusions from the results.

Objective 2. Spider mite populations will be measured in several raspberry fields in August or early September. Populations of overwintering predators will be measured by trapping to determine if there is any correlation between mite and predator numbers. Spider mite populations will be measured in the following late spring and summer to determine the effect of the predators on them.

Objective 3. Trap-colonies of spider mites will be initiated shortly after foliage appears in the spring. These experimental infestations will be used to monitor the density and reproductive rates of native predator species.

TERMINAL DATE OF BASE PROJECT: March 31, 1991.

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

BUDGET:

		1990-91	1991-92
01	Wages	$7,000[a]	$7,000[a]
03	Supplies	500	500
04	Travel	1,500	1,500
07	Benefits	350	350
Total		$9,350	$9,350

[a] $5,000 for 2 months research by Ph.D. entomologist, $2,000 for student assistant.

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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 andExtension 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. One class of compounds, the diphenyl ethers, has shown considerable promise in field trials.

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. This is of particular importance when dealing with chemicals such as diphenyl ethers, contact herbicides which are strong mitotic poisons. 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.

PROGRESS: In 1990 this project continued with a third year of testing of three dinoseb alternatives in replicated plots at Vancouver and Mt. Vernon. These three compounds, oxyfluorfen, acifluorfen, and lactofen (tradenames respectively Goal, Tackle/Blazer, and Cobra) were applied once to newly emerging primocanes at five different rates: 0.1, .2, .4, .8, and 1.6 lbs/A. Other treatment groups included one receiving two applications of dinoseb and an untreated control. Before and during harvest, yield component analysis was performed in which vegetative measurements and numbers of canes, laterals, fruit, flowers, and fruit weight were recorded for estimation of yield potential.

In 1988, the seven-year-old commercial field (yearly primocane control) at Mt. Vernon showed no differential response in the first year. The seven-year-old field at Vancouver with no previous primocane control responded with positive correlation between herbicide rate and berry weight, and a negative relationship between rate and primocane heighth after harvest. In 1990, after three years of application, higher rates of the tested compounds have visibly reduced cane numbers, height, and diameter. As we predicted in 1989, a third year of application (1990) of Goal and Cobra at higher rates negatively influenced growth and productivity. Three years of application of Goal resulted in reduced berry size, yield per cane , cane heighth and diameter as rate increased. 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.

In 1990, our first season without dinoseb, a Section 18 was obtained for Goal for use on red raspberry. Problems experienced in primocane suppression with Goal in 1990 were the result of a number of factors. Experience in 1990 has underscored the importance of accurate application techniques as well as the need for further investigation as to the interactions among the plant, the chemical and the envionmental conditions prior to, and during application.

PROPOSED RESEARCH: In 1991, the same experiment will be repeated at both sites in the same plots. The primocane suppression characteristics of each material 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 1991 season will allow us to continue to evaluate the potential problems associated with the long-term use of these materials.

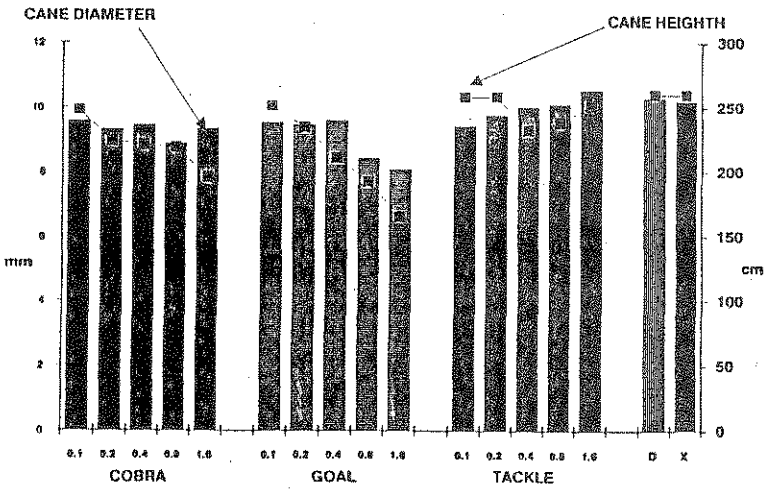
Additional studies are also being planned for 1991 with regards to the basic physiological responses of red raspberry to oxyfluorfen. These studies will help to characterize the biochemical and physiological consequences of short-term and long-term use patterns with this very potent herbicide. This research would involve measurements of photosynthetic response, fourth-derivative spectroscopy of photosynthetic action spectra, SDS polyacrilamide gel electrophoresis, and anatomical studies.

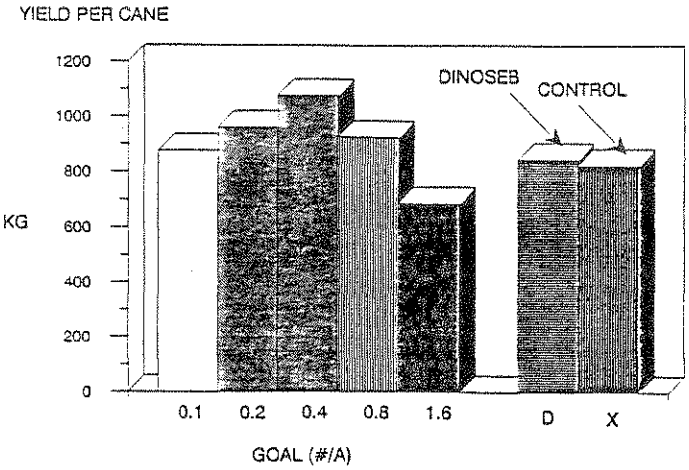
TERMINAL DATE OF BASE PROJECT: 10A-3555-0783; June 30, 1993

DURATION OF THIS PROJECT: We request renewal of this project for an additional three years. Oxyfluorfen is currently the only primocane control chemical which has potential for registration. The 1990 season demonstrated that need to know much more about the interaction of Goal with the plant and environmental preconditioning as well as the long term effects of oxyfluorfen on plant growth.

BUDGET:

		Vancouver	Mt. Vernon
01	Temporary employees	$3,000	$3,000
03	Supplies and services	400	400
05	Computer services	350	----
06	Travel	----	350
07	Benefits (5% of 01)	150	150
	SUBTOTAL EACH SITE	$3,900	$3,900
	TOTAL	$7,800	





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, by providing 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 and 1990 we continued this project by following the development of leaves on fruiting and defruited canes. Beginning at anthesis and continuing over a 17-week period, leaves from fruiting and nonfruiting canes were sampled for physiological and anatomical analyses. Leaves were prepared each week for thin sectioning, staining and microscopic examination of leaf anatomy. Photosynthetic action spectra of sampled leaves were characterized by fourth derivative spectroscopy using a scanning spectrophotometer equipped with an integrating

sphere. Analyses of chlorophyll content and specific leaf weight were also performed weekly. Gas exchange measurements were made as weather permitted. In parallel work, large numbers of fruiting and deflowered laterals were analyzed node by node with regards to carbon dynamics. Each of up to 14 nodes from the tip to the base of each lateral were measured for photosynthetic rates, fruit load, leaf area and specific leaf weight.

In general, leaves from fruiting and nonfruiting laterals are different in a number of ways including dry weight accumulation, chlorophyll content and anatomical characteristics. We now know that raspberry leaves accumulate starch during the late morning hours when photosynthesis is peaking, and that leaf starch content declines until late afternoon when an early evening increase is followed by a decline overnight. 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.

It is clear that the red raspberry is capable of considerable compensation among its components of yield, and it appears that we have observed compensation at the physiological level which may correlate well with whole-plant relationships. Our research has shown that red raspberry leaves can compensate for loss of photosynthetic surface area up to about 30%. The practical applications of this information apply to every facet of raspberry culture. For example, in conjunction with Dr. Carl Shanks, we have demonstrated the physiological costs associated with low levels of spider mite feeding. With Dr. Peter Bristow, we have shown that wet soils and root rot can significantly reduce physiological processes and productivity. In addition, we have shown that pesticides can interfere with photosynthetic processes. Additional stresses such as other insects and diseases and extremes in weather could additionally reduce physiological processes to the point where the plant might utilize stored reserves at the expense of growth or will allocate fewer resources to fruit. Modelling carbon balance in a biennial, fruit-bearing plant is very difficult, but we are gaining a much clearer understanding of how the development of this plant is influenced by physiological changes during fruiting.

PROPOSED RESEARCH: In 1991, we will continue to model the response of red raspberry to assimilate demand by repeating parts of the 1989-90 experiments involving gas exchange, light interception, yield compents and leaf anatomy. These types of measurements will also be made after manipulating leaf:fruit ratio on entire

canes of 'Meeker' within the canopy. In 1991 we will also start to integrate information from our other projects concerning the impact of pests and pesticides on carbon dynamics. 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.

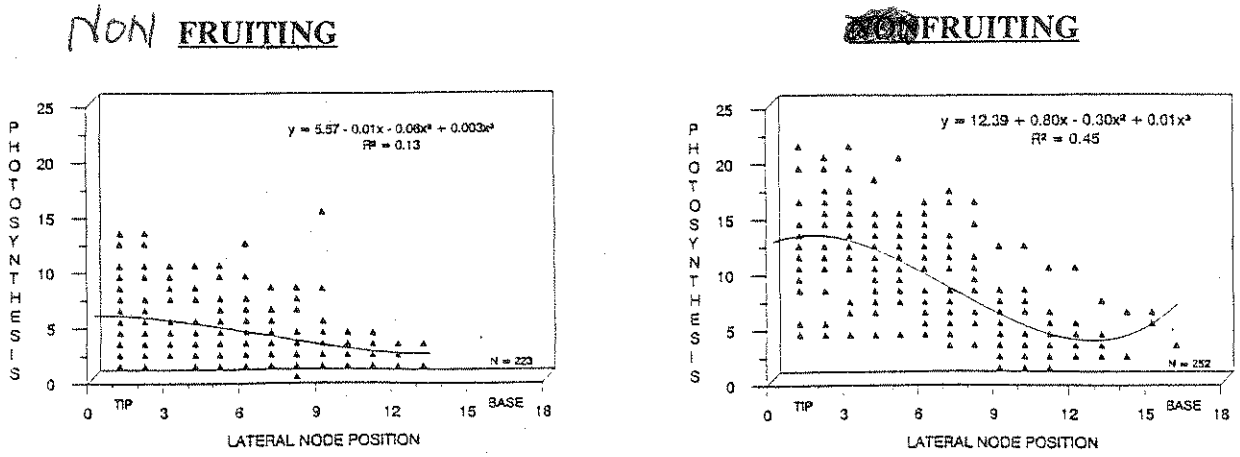
TERMINAL DATE OF BASE PROJECT: June 30, 1993

DURATION OF THIS PROJECT: We request a three year extension of this project so that we may work towards developing a working model of red raspberry carbon dynamics which can be used for optimizing cultural management and pest control strategies.

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

		1990	1991
01	Temporary employees	$2,000	$2,500
03	Supplies and services	300	175
05	Computer services	100	800
07	Benefits (5% of 01)	100	125
TOTAL		$2,500	$3,600

Figure 1. Photosynthetic rates of leaves along fruiting and nonfruiting laterals of 'Meeker' red raspberry.



PROJECT NO.: 13C-3555-5956

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 various cultural treatments which manipulated soil moisture and temperature, and thus demonstrated that MP raspberry plants do 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 initiated in late summer of 1989. 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 arranged in 12 blocks containing one plant of each of the four treatments. At that time, 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. Destructive sampling was done in one third (four) of the blocks as 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 (Table 1). MP plants had nearly twice as many canes per plant, but they were slightly smaller. Mowing increased cane size but not cane number.

Table 1. The influence of mowing and propagation method on primocane characteristics of 'Centennial' red raspberry plants during establishment.

Cane:	MP	CP	% +/-	Mowed	Unmowed	% +/-
Number	29.3	15.8	+85%	20.4	24.7	-21%
Length (cm)	120.2	133.6	-11%	143.8	110.1	+30%
Diameter (mm)	7.8	8.9	-14%	8.9	7.8	+14%
Node number	26.7	28.2	-06%	29.9	25.0	+20%

All comparisons significant by HSD at 5%.

From the results of this study it appears that MP plants have an establishment advantage in terms of increasing numbers of canes per plant, and that mowing may help in maximizing their size.

PROPOSED RESEARCH: In 1991, we will complete the 'Centennial' pot study and analyze the fruiting behavior of primocanes produced in 1990. This will allow us to determine the influence of propagation method and mowing on reproductive behavior. Yield component and dry matter partitioning analyses will be performed in order to determine whether increased mowed/MP cane numbers and length will convey a reproductive advantage.

With the knowledge gained by our research and that conducted in New York, we propose a final experiment which will allow us to make a recommendation to our industry on how to maximize the apparent advantages which MP planting stock might offer through proper establishment and cultural management protocols. A second field planting will be established with MP and CP plants of 'Meeker' and 'Willamette' planted in the Spring and mowed in the Fall or planted in the Fall and mowed in the Spring. Vegetative measurements will be made on primocanes in 1992 in order to evaluate degree of establishment. In 1993, reproductive measurements will be made in order to evaluate yield potential and fruit distribution among the treatments.

TERMINAL DATE OF BASE PROJECT: June 30, 1993

DURATION OF THIS PROJECT: Based upon the results of our work in 1990, we are requesting an extension of this project for three years in order to develop recommendations to the industry for protocols in establishing micropropagated planting stock. Funding is requested in order to complete the pot study established with 'Centennial' and to establish a field trial of mowed and unmowed MP and CP plants at different dates.

BUDGET: Funding in 1991 will be used to provide labor and supplies so that we might complete the large pot study and establish a field trial.

		1990	1991
01	Temporary employees	$1,800	$2,600
03	Supplies and services	600	670
05	Computer services	-----	100
07	Benefits (5% of 01)	90	130
	TOTAL	$2,490	$3,500

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 (Project #13C-3543-7956), 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. In some cases, feeding by only a few mites on one part of a plant appeared to have influenced the physiology of leaves which had not been exposed to mite attack. This suggests that red raspberry may respond to mite feeding in some manner which profoundly influences the physiology of the whole plant. 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: Data from our 1988 study on the physiological response of red raspberry to mite feeding was thoroughly re-analyzed in 1990. New information from this data has given us a better understanding of how mite feeding influences photosynthetic processes. When mite populations were correlated 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%. Experiments currently in progress will be discussed when we meet with the commission in December. We are testing the physiological influence of mite feeding on single leaflets and isolated adjacent leaves. This will further characterize the nature of this response as we measure the speed of the response and determine the extent of influence from a localized attack. Preliminary evidence in our research has shown that uninfested leaves on plants where mites are feeding somewhere else on the plant will also have lower photosynthetic rate, thus suggesting a translocatable influence within the plant. Spectroscopy and electrophoretic techniques will be used in order to characterize the influence of mite feeding on chlorophyll content, chlorophyll-protein complexes, and general metabolism of leaves.

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

Figure 1. The influence of mite number per leaflet on carbon dioxide assimilation rate (photosynthesis). The position on the graph marked by an arrow represents 25 mites per leaflet.

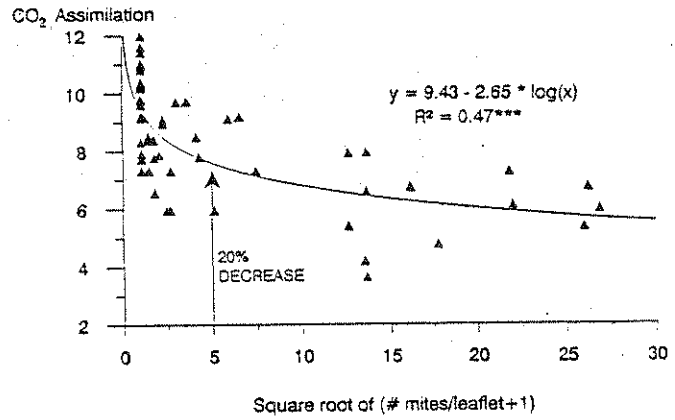


Figure 2. The influence of mite number per leaflet on mesophyll conductance. The position on the graph marked by an arrow represents 25 mites per leaflet.

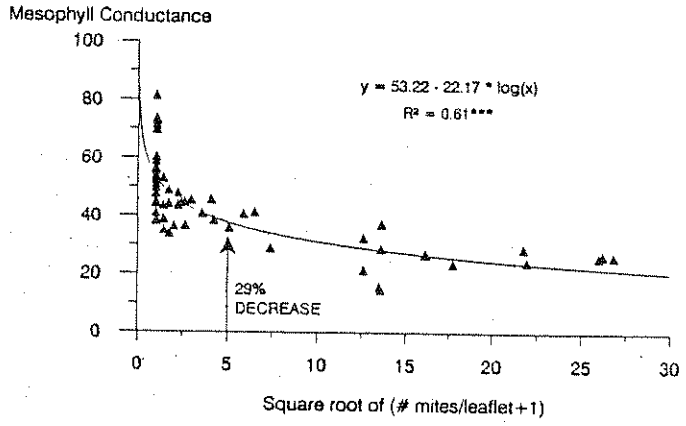
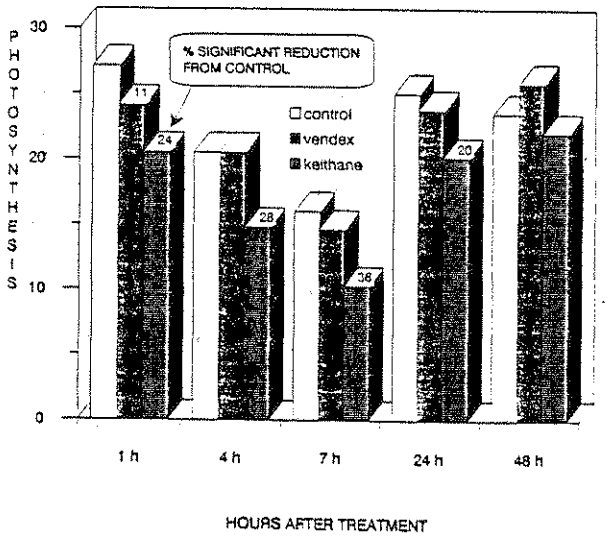


Figure 3. The influence of the miticides Vendex and Kelthane on photosynthesis.



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 to sample variability.

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. Potted plants in the growth chamber and greenhouse will be used to allow for repetitive experiments and for uniformity of plant material and environment. 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, 1991 (CHS)

DURATION OF THIS PROJECT: One year with the possibility of renewal depending upon the results obtained in 1991.

BUDGET:

		1990	1991
01	Temporary employees	$900	$1200
03	Supplies and services	500	500
05	Computer services	100	500
07	Benefits (5% of 01)	45	60
	TOTAL	$1,545	$2,260

PROJECT NO: 13L-3419-4840

TITLE: Development of a Best Management Practice Manual for Red Raspberries

PERSONNEL: Stott W. Howard, Ext. Weed Scientist
Craig B. MacConnell, Chairman, Whatcom Co. Coop. Ext.

PROGRESS: With the resignation of Dr. Howard, and other problems, the research was not continued. The funds will be returned to the funding organization for reallocation.

PROJECT NO: 13L-3419-3840

TITLE: Evaluation of Living Mulches for Red Raspberries

PERSONNEL: Stott W. Howard, Ext. Weed Scientist
Carl Libbey & Eric Hall

PROGRESS: No progress was made on this proposal. The funds will be returned to the funding organization for reallocation.

Project No:

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

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~~ 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 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 been in contact with the group at Scottish Crops Research Institute and will be testing their raspberry transformation protocols in this first year

Proposed Research:

We will clone and sequence the coat protein of RBDV. This requires the purification of the virus, extraction of the viral RNA, making a double stranded DNA copy of the RNA, identifying the coat protein gene of the virus, and sequencing this gene. The purification of RBDV we have done before when we made monoclonal antibodies to this virus and this is a relatively easy virus to purify. We have also carried out the RNA extraction from purified RBDV. I have made cDNA to several different viruses and have sequenced several different viruses so this technology is available in my lab. These methods are all quite straight forward but very labor intensive.

The second and third year of this project I plan to 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: 2/3

Budget:	1990-91	Proposed for 1991-92
03 Goods and Services	5000.00	5000.00
04 Travel		500.00
TOTAL	5000.00	5500.00

I have a student that is now working on this project. The students' salary is being paid by a scholarship program. The enzymes, radioisotopes, platicware and other supplies are quite expensive for this work, that is why most of the budget is being used on good and services. The travel budget is to help cover the costs of attending the International Small Fruit Conference in 1991.

Project No. :

Title: Transformation of Raspberry with the Coat Protein Gene of Tomato Ringspot Virus.

Personnel: D'Ann Rochon and R.R. Martin, Research Scientists, Agriculture Canada Research Station, Vancouver, B.C. Canada

Justification: Tomato ringspot virus (TomRSV) can be a serious problem in red raspberry in the Pacific Northwest. Currently, there are no known raspberry cultivars that are resistant to TomRSV. Recently, it has been demonstrated in several independent investigations that virus resistance can be conferred to plants by incorporating into the plant the coat protein gene of the virus to which resistance is desired. Transformation of raspberry with the coat protein gene of TomRSV may similarly result in the development TomRSV-resistant raspberry.

Objectives: The ultimate objective of this project is to obtain raspberry cultivars which are resistant to TomRSV infection. This requires the completion (in the following order) of the following sub-objectives (see also below):

1. Cloning, identification and sequencing of the region of the TomRSV genome which contains the coat protein gene.

2. Development of tissue culture methods for transforming and regenerating raspberry plants.

3. Testing of transformed raspberry plants for expression of the TomRSV coat protein gene.

4. Greenhouse and field testing of regenerated plants for TomRSV resistance.

Progress: The tomato ringspot virus genome is being analyzed as part of a larger project to determine TomRSV genes involved in plant disease. To this end, both TomRSV RNA components have been cloned and all of RNA-2 has been sequenced. This work has enabled the identification of the region on TomRSV RNA-2 which encodes the coat protein (see sub-objective #1 above). It is anticipated that tissue culture methods for transforming and regenerating raspberry should be completed by the spring of 1991 especially since a protocol describing these recently developed methods has been provided to us by researchers at the Scottish Crop Research Institute.

Proposed Research: As mentioned in the objectives section of this proposal, this project consists of 4 sub-objectives which will be carried out as described below.

1. *Cloning, identification and sequencing of the region of the TomRSV genome which contains the coat protein gene.* This project objective which required approximately 1 full year of full-time effort has already been met.

2. *Development of tissue culture methods for transforming and regenerating raspberry plants.* Conditions required for the successful transformation and regeneration of raspberry will be developed. Transformation will be attempted using *Agrobacterium tumefaciens* and commercially available modified *A. tumefaciens* Ti plasmid DNA vectors containing the TomRSV coat protein gene. Optimal conditions for regeneration of transformed plants will

TITLE: Development of virus-tested red raspberry cultivars

PERSONNEL: Lloyd W. Martin, North Willamette Research and Extension Center

Ms. Elzibeth Volk, Research Assistant, Dept. of Botany & Plant Pathology, Oregon State University, Corvallis, OR 97331

JUSTIFICATION:

For a number of years mother plants for most of the commercial red raspberry planting stock used in Washington State have originated in the USDA-ARS virus-tested small fruit stock program at Oregon State University in Corvallis, OR. In calendar 1990, thanks to special efforts by Oregon State University, this program was continued and will continue in 1991 so that the stocks tested for virus freedom, and currently being increased in a screenhouse (see below) can be distributed as usual to requesting State Departments of Agriculture for nurseries participating in their certification programs. R.H. Converse retired September 30, 1990 and the program, while still using ARS facilities and supplies, will be continued by Ms. Elzibeth Volk under the supervision of Dr. Lloyd Martin, Professor of Horticulture at OSU.

OBJECTIVES;

1. Test for virus content clones of major commercial red raspberry cultivars and advanced selections developed for the Pacific Northwest.

2. Eliminate viruses in these clones by a combination of heat therapy in an atmosphere of elevated carbon dioxide, followed by shoot apex tissue culture and plant regeneration.

3. Increase and distribute propagants of tested clones to requesting public agencies.

PROGRESS:

1. Ten red raspberry cvs (Amity 85M, August Red 85HT, Canby 81M, Chilcotin 86M, Comox, Heritage 86M, Meeker 81M, Skeena 79, Summit 89M and Willamette 80M (numbers following cvs indicate year of release of the virus-tested clone; M denotes that it is a meristem clone); and four ORUS red raspberry advanced selections (576-47 ORUSM 119, 716-4, 932-2, and 1836 ORUSM 162) were sent to requesting Departments of Agriculture and Agriculture Experiment Stations in March, 1990, in Washington, Oregon and California.

2. No known source of the cultivar Fallgold is free of raspberry bush dwarf virus. It has been an unusually difficult cultivar to handle in the heat chamber and in tissue culture. Currently, several explants are slowly regenerating virus evaluation in the spring of 1991 but will not be ready for public release until 1992, at the earliest.

3. The following advanced selections from the ORUS raspberry breeding program were given to us during 1990 by Drs. F.J. Lawrence and L.W. Martin for virus evaluation, heat therapy and shoot tip propagation: 1734, 959R-1, and 979-2. They are currently in various stages of this process. This work will be continued in 1991.

PROPOSED RESEARCH;

In 1991 under the direction of Dr. L.W. Martin, Ms. Elzibeth Volk will plan: a) to release dormant stocks of the commercial red raspberry cultivars and (under cooperative agreement) ORUS selections currently being increased in the USDA-ARS HCRL screenhouse to requesting public agencies in March 1991; b) to retest for possible virus infection selected mother plants of the present group of cultivars and ORUS selections; and c) to continue the process of virus testing, heat therapy and shoot tip culture, followed by subsequent regeneration and virus testing to develop clean clones of new advanced red raspberry selections for future distribution as administratively determined.

TERMINAL DATE: December 31, 1991

DURATION OF THIS PROPOSAL: On-going

BUDGET:

	Jan-Dec, 1991
00 Salary	$3,268
01 Benefits (37.7%)	1,232
TOTAL	$4,500

REQUESTED BY:

Lloyd W. Martin 10-26-90

Lloyd W. Martin, Superintendent
North Willamette Research and
Extension Center

APPROVED BY:

V. V. Volk 10/30/90

for Thayne R. Dutson, Director
Agricultural Experiment Station

R. A. Scanlan 11-1-90

Richard A. Scanlan
Dean of Research

Clem Fa Cava 11-1-90

for Business Services Manager

Project No.: New

Title: Evaluation of Margosan-O, a Neem based botanical insecticide, as a control for Black vine weevil.

Personnel: John D. Stark, Entomologist/Environmental Toxicologist, WSU Puyallup, Puyallup WA

Arthur Antonelli, Extension Entomologist, WSU Puyallup, Puyallup WA

Carl Shanks, Entomologist, WSU-Vancouver Unit, Vancouver, WA

Justification:

Recently, a great deal of effort has been devoted to the search for alternatives to synthetic insecticides because of problems associated with the use of these chemicals such as environmental contamination and the development of resistance. Plant-derived chemicals have received a large amount of attention and interest in botanical insecticides has grown rapidly. One of the most promising compounds, azadirachtin, a limonoid or tetranorterpinoid, a component of leaves and fruits of the Neem tree, *Azadirachta indica* A. Juss., is commercially available (Margosan-O, W. R. Grace & Co., Columbia, Maryland) for non-food crops. Azadirachtin and neem seed extracts are effective controls for a wide variety of pest insects. Neem insecticides have been readily accepted by many organic farmers and azadirachtin appears to be safe with an acute oral toxicity in rats greater than 5000 mg/kg (Azadirachtin is more than 450 times less toxic than Furadan). Because Furadan has been found to contaminate ground water and is not providing effective control due to enhanced microbial degradation, its future use is in question. W. R. Grace & Co. is pursuing a food-crop registration and has not decided which pests will be included on the label. Therefore, it is important that this product be evaluated as an alternate insecticide against the pests of raspberry. Stark et al. (1990) have shown that Margosan-O is an effective soil treatment for the control of Mediterranean fruit fly and does not negatively affect parasites of fruit flies. Margosan-O is a good candidate insecticide to replace some synthetic insecticides but there are no published data on its ability to control pests of raspberries in the Pacific Northwest. If Margosan-O is found to be a good control agent for black vine weevil, this product could be used instead of Furadan provided registration can be obtained.

Ojective:

Determine whether Margosan-O is an effective and economical control agent for Black vine weevil.

Proposed Research:

A series of replicated laboratory and field tests will be conducted to examine the effectiveness of Margosan-O as a control for Black vine weevil, *Otiorhynchus sulcatus*. Laboratory evaluations will involve soil bioassays and/or topical application to determine acute and chronic effects. Lethal dose values (LD or LC_{50}) and effects on reproduction of individuals treated with sublethal doses of Margosan-O will be determined. Field evaluations will compare Margosan-O and current chemical controls (Furadan) and an untreated control plot. Insecticides will be applied as a soil drench to preexisting raspberry plantings. Plant damage, crop yield and the number of larvae present in soil will be determined.

Duration of Base Project: 1 year

Budget:

Goods & Services.....	$1000
Total.....	$1000

Proposed Research:

A series of replicated laboratory and field tests will be conducted to examine the effectiveness of Margosan-O as a control for Black vine weevil, *Otiorhynchus sulcatus*. Laboratory evaluations will involve soil bioassays and/or topical application to determine acute and chronic effects. Lethal dose values (LD or LC_{50}) and effects on reproduction of individuals treated with sublethal doses of Margosan-O will be determined. Field evaluations will compare Margosan-O and current chemical controls (Furadan) and an untreated control plot. Insecticides will be applied as a soil drench to preexisting raspberry plantings. Plant damage, crop yield and the number of larvae present in soil will be determined.

Duration of Base Project: 1 year

Budget:

Goods & Services.....	$1000
Total.....	$1000