1994
RED RASPBERRY RESEARCH PROPOSALS

1993 PROGRESS REPORTS

to the

WASHINGTON STATE RED RASPBERRY COMMISSION

and

NORTHWEST RED RASPBERRY GROWERS ASSOCIATION

WASHINGTON RED RASPBERRY COMMISSION

1993-94

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Project: 13C-3755-5641

Title: Red Raspberry Breeding, Genetics and Clone Evaluation

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

Reporting Period: 1993

Accomplishments: In 1993, 44 crosses were made. Twenty eight of the crosses used clones with large fruit that was a result of either large drupelets or many drupelets per fruit. The remaining crosses used clones which have been in the field at Puyallup for many years, and remain RBDV free. Seedlings from these crosses will be planted in 1994 and evaluated in 1996 and 1997. Almost 5,000 seedlings from the 1992 crosses were planted at Puyallup and additional plants from these crosses were planted at Corvallis. Thirty two clones were planted in replicated yield trials at Puyallup and two additional clones were included in non-replicated plots. Seventeen selections were made among over 2,600 seedlings planted in 1991. WSU 1021, WSU 1020, Summit, and Tulameen were the best parents. Three of these selections were fall fruiting. This seedling planting will remain for additional evaluation and selection in 1994. All plants in selection trials and breeding plots were tested by Dr. Bob Martin (Agriculture Canada) for RBDV and TSV. Plants testing positive were eliminated.

A portion of the 1990 selection trial was harvested for the second time in 1993 (Table 1). WSU 1027, a yellow fruited selection, was the highest yielding clone, but not significantly higher yielding than WSU 1024 the highest yielding clone in 1992. WSU 1020 continued to have exceptional fruit firmness.

The 1991 selection trial was harvested for the first time in 1993 (Table 2). Many clones were present in only one or two plots and those values should be compared with caution. Tulameen had the highest yield, but not the largest fruit. WSU 1030 is a large, yellow fruiting selection that appears promising. WSU 1041 had high yields of large, firm fruit with a harvest season similar to Willamette. WSU 991 had large, firm fruit but the yield was not high in 1993. First year yields are not closely correlated with later yields.

1992 fruit samples were frozen and analyzed for parameters of fruit characteristics (Table 3).

Publications:

Moore, P.P. 1993. Chloroplast DNA diversity in raspberry. J. Amer. Soc. Hort. Sci. 118:371-376.

Dale, A., P.P. Moore, R.J. McNicol, T.M. Sjulin, and L.A. Burmistrov. 1993. Genetic diversity of red raspberry cultivars throughout the world. J. Amer. Soc. Hort. Sci. 118:119-129.

Moore, P.P. 1992. Floricane fruiting red raspberry cultivars in the Pacific Northwest. Fruit Var. J. 46:200-202.

Robbins, J.A. and P.P. Moore. 1992. Fruit quality of stored, fresh red raspberries after a delay in precooling. HortTechnology 2:468-470.

Moore, P.P. and H.A. Daubeny. 1993. 'Meeker' red raspberry. Fruit Var. J. 47:2-4.

Moore, P.P. 1993. Small fruit cultivar characteristics. Proc. West. Wash. Hort. Assoc. 83:106-109.

Moore, P.P. Variation in drupelet number and drupelet weight among raspberry clones in Washington. Acta Hort. (Rubus and Ribes Symposium) (In press).

Moore, P.P. Yield compensation of red raspberry to primary bud removal. HortSci (In review).

Presentations

January, 1993. Display of strawberries and raspberries. Western Wash. Hort. Assoc. Tacoma, WA.

January, 1993. Display of strawberries and raspberries. Northwest Food Processors, Portland, OR.

February, 1993. Display of raspberries. Oregon Raspberry and Blackberry Commission. Aurora, OR.

July, 1993. Raspberry Field Day. Puyallup, WA.

August, 1993. Display of strawberries and raspberries. Agriculture Showcase. Yakima, WA.

Table 1. 1992-93 harvests of 1990 planted raspberry at Puyallup, WA.

	Yield (t/a)				Fruit weight	Fruit firmness	Fruit rot	Harvest season				
	1993		1992	total	(g)	(g)	(%)	5% harvest	50% harvest	95% harvest	length of season	
WSU 1024	11.1	A	10.0	21.1	4.0 B - C	141 B	3.7% B - C	7/2	B 7/12	B 7/27	B 25 C - D	
WSU 1027	12.0	A	7.8	19.8	3.9 C	110 D	5.0% B	6/23 E - D	7/4	E 7/20	E 27 B - C	
MEEKER	10.7		7.4	18.1	3.2	95	1.8%	6/29	7/10	7/25	26	
WILLAMETTE	9.5		6.1	15.6	3.5	123	1.6%	6/23	7/3	7/18	26	
WSU 1026	10.5		4.8	15.3	3.4	104	3.8%	6/23	7/5	7/24	31	
WSU 1020	7.4		7.5	14.9	4.4	252	2.3%	6/29	7/14	7/28	29	
WSU 1017	7.9		6.9	14.8	3.6	96	2.7%	6/29	7/11	7/25	26	
WSU 1021	9.3		4.9	14.3	3.4	139	5.0%	6/29	7/17	8/3	35	
CHILCOTIN	9.1 A - B		5.1	14.2	3.4 D	88 E	4.0% B - C	6/22 E	7/4	E 7/24	D 32	A
WSU 1019	6.6		7.0	13.5	2.8	90	5.6%	6/30	7/15	8/1	32	
CHILLIWACK	7.9		5.1	13.1	3.2	120	2.4%	6/27	7/9	7/24	27	
WSU 1022	7.3		5.8	13.1	2.9	90	3.3%	6/26	7/9	7/24	28	
WSU 1018	6.6 B - C		6.5	13.0	2.6 E	84 E	2.7% C	6/24 D	7/8 C - D	7/23 D	28	B
WSU 1013	7.2		4.6	11.8	3.6	115	4.2%	6/27	7/8	7/23	26	
WSU 1015	7.9 B - C		3.4	11.4	3.4 D	131 B - C	2.3% C	6/23 D - E	7/6	D 7/24 C - D	31	A
WSU 1023	6.4 B - C		4.7	11.1	5.2 A	112 D	3.3% B - C	6/28 C	7/8	C 7/23 D	24	D
WSU 1012	6.7 B - C		3.7	10.4	2.9 E	122 C - D	4.0% B - C	7/2 B	7/13	B 7/26 B - C	24	D
WSU 1025	5.0	C	3.2	8.1	4.3 B	164 A	10.3% A	7/11 A	7/21	A 8/5 A	25 C - D	
Average	8.3		5.8	14.1	3.5	121	3.8%	6/27	7/10	7/25	28	

Means are averages of three 3 hill plots at 3 ft x 8 ft spacing

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

Means not followed by a letter are means of one or two plots and not included in the statistical analyses.

Table 2. 1993 harvests of 1991 planted raspberry at Puyallup, WA.

	Yield (t/a)	Fruit weight (g)	Fruit firmness (g)	Fruit rot (%)	Harvest season 5% harvest	50% harvest	95% harvest	length of season
TULAMEEN	7.8	4.1	119	5.0%	6/27	7/10	7/25	28
WSU 992	6.8 A	4.1 B - C	95 E	13.0% A	6/29 A	7/13 A	7/25 A	26 A - C
WSU 1035	6.6 A - B	4.1 C - D	111 C - E	5.7% C - D	6/24 C	7/6 C - E	7/18 C - D	24 A - E
WSU 1030	6.3 A - C	4.6 B	142 B	5.3% C - D	6/21 D	7/5 E - F	7/19 B - C	28 A
WSU 1041	6.1 A - C	4.4 B - C	137 B - C	12.7% A	6/21 D	6/30 I	7/11 E - F	20 E - F
WSU 1031	5.6 A - D	5.0 A	92 E	8.7% A - C	6/25 B - C	7/7 B - D	7/20 B - C	25 A - D
WSU 1045	5.4 A - D	4.4 B - C	129 B - C	6.7% C - D	7/1 A	7/11 A	7/24 A - B	23 B - E
WSU 1044	5.2 A - D	3.3 E - F	124 B - D	7.0% C - D	6/21 D	6/30 I	7/14 D - F	23 B - E
MEEKER	5.1 A - E	3.2 F	90 E	3.0% D	6/24 B - C	7/7 B - E	7/21 A - C	27 A
BC 83-16-50	5.0 A - E	4.4 B - C	130 B - C	7.0% C - D	6/26 B	7/9 B	7/22 A - C	26 A - B
WSU 1046	4.7	3.9	125	3.2%	6/25	7/7	7/19	25
WSU 1039	4.7 B - F	4.4 B - C	112 C - E	7.7% B - D	6/23 C - D	7/3 G - H	7/15 D - E	22 D - F
WILLAMETTE	4.3 C - F	3.6 D - E	124 B - D	7.0% C - D	6/22 D	7/1 H - I	7/12 E - F	20 E - F
WSU 1040	3.7 D - F	5.2 A	188 A	12.3% A - B	6/22 D	6/30 I	7/10 F	18 F
WSU 1038	3.3	3.0	132	2.9%	6/19	6/29	7/13	24
WSU 1037	3.3	4.0	125	5.9%	6/24	7/3	7/15	21
WSU 1033	3.2 E - F	4.3 B - C	100 D - E	5.0% C - D	6/24 B - C	7/5 D - F	7/18 C - D	24 A - E
WSU 1032	2.9 F	3.6 D - E	101 D - E	6.0% C - D	6/26 B	7/8 B - C	7/18 C - D	22 C - F
WSU 991	2.7 F	4.4 B - C	130 B - C	7.7% B - D	6/21 D	7/4 F - G	7/14 D - F	23 B - E
WSU 1036	1.9	3.1	79	12.2%	6/29	7/9	7/19	20
Average	4.7	4.1	119	7.2%	6/24	7/5	7/17	23

Means are averages of three 3 hill plots at 3 ft x 8 ft spacing

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

Means not followed by a letter are means of one or two plots and not included in the statistical analyses.

Table 3. Analysis of 1992 raspberry fruit grown at Puyallup, WA

	pH	Soluble Solids (%)	Titratable Acidity as % citric acid	Anthocyanins A @ 531 nm equivalent to 14 g fr in 1000 ml
CHILLIWACK	3.01 B - C	12.3 A	1.22 B - C	0.681 A
COMOX	2.86 D F	9.6 D - E	1.48 A	0.630 A - B
MEEKER	3.09 B A	11.8 A - B	0.94 E	0.495 C - D
WILLAMETTE	2.94 C - E	8.7 F	1.27 B	0.547 B - C
WSU 933	3.01 E - C	11.0 C	1.14 B - D	0.386 D - F
WSU 983	2.98 A - D	12.2 A	0.91 E	0.430 C - E
WSU 984	2.90 C - F	9.6 D - E	1.20 B - D	0.275 F
WSU 988	3.05 E - B	8.6 F	1.11 B - E	0.527 B - C
WSU 991	2.95 - E	10.8 C	1.27 B	0.011 G
WSU 994	2.90 - F	8.3 F	1.19 B - D	0.299 F
WSU 1006	3.00 - C	11.1 B - C	1.01 D - E	0.338 E - F
WSU 1007	2.95 E - E	12.2 A	1.02 C - E	0.478 C - D
WSU 1009	2.85 C F	8.7 F	1.26 B	0.436 C - E
WSU 1020	2.89 B - F	9.7 D	1.62 A	0.459 C - E
WSU 1021	2.98 C - D	9.0 E - F	1.28 B	0.689 A
Average	2.96	10.3	1.19	0.445

Means of five samples of 10 grams for each clone.

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

Project: 13C-3755-5641

Title: Red Raspberry Breeding, Genetics and Clone Evaluation

Year Initiated: 1994 **Current Year** 1994 **Terminating year** 1997

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

Justification:

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

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

Objective:

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

Procedures:

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

1. Crosses will be made for summer fruiting cultivar development. Clones identified by ongoing cold hardiness, disease and insect resistance, fruit color, and drupelet number studies will be used as parents. Other important traits included are ease of fruit removal, fruit firmness, fruit size, fruit color, harvest season, fruit rot resistance, and growth form.

2. Forty four crosses were made in 1993. When possible, 100 seedlings will be planted for each cross. Selections will be made among these seedlings in 1996 and 1997.

3. Selections will be made among the 2,600 seedlings planted in 1991 and the almost 2,000 seedlings planted in 1992. Seedlings will be subjectively evaluated for yield, flavor, appearance, color, harvest season and growth form. For promising seedlings, fruit size, color, and firmness will be measured. Based on these observations, seedlings will be selected for propagation and further evaluation. Typically the best 1% or less of a seedling population will be selected.

4. Seedlings selected in 1993 (17 selections) will be propagated for testing in three replications of three hill plots and compared to standard cultivars. Selections will be evaluated for yield, fruit size, fruit firmness, fruit rot, and harvest season as well as pest and disease resistance in 1996 and 1997.

5. The replicated planting established in 1991 will be harvested for the second year. The replicated planting established in 1992 will be harvested for the first time.

6. After these evaluations, roots of promising selections will be dug from field plots at Puyallup winter 1993 and planted at Puyallup to produce field grown plants for distribution to growers in 1995. These plants will then be tested at additional locations. At the same time, selections will be placed in trials with cooperating commercial growers for grower and processor evaluation.

   WSU 992, WSU 1035, WSU 1030, WSU 1031, WSU 1041 are the most promising selections in the 1991 selection trial based on the first year's harvests and roots of these selections will be dug and field propagated. If these selections perform well in 1994, field grown plants will be available for grower trials. If these selections do not perform well, the plants will be discarded.

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

Anticipated Benefits and Information Transfer:

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

Proposed Budget:

Support is requested for a portion of the project operations budget. Salaries for one WSU faculty member, two support staff, and $1,400 operating funds are provided by WSU for breeding work on BOTH raspberries and strawberries. This request will provide for funding for 0.40 of the salary and benefits of a classified staff position for raspberry work at WSU Puyallup. The Technical Farm Laborer position is currently being upgraded to a Agricultural Research Technologist I with same person in the position. The remaining 0.60 FTE will be funded for 1994-95 by other commissions. Remaining funds would be used for hiring timeslip help for harvests and data collection, pots, soil, other supplies and travel. Travel would be to local grower meetings and to research plots. Funds are requested to purchase a seed counter to facilitate studies on drupelet number and drupelet weight. In 1993, seed from over 1,500 fruit were counted, approximately 150,000 seed.

	1993-94	1994-95
00 Salaries		
(Tech. Farm Laborer)	$11,051(0.45 FTE)	0
(Ag. Res Tech I)	0	$10,168 (0.4FTE)
(Plant Tech. II 1/12 FTE	2,605	0
01 Timeslip labor	4,000	4,000
03 Service and supplies	4,019	4,154
04 Travel	300	400
06 Equipment	0	3,200
07 Benefits		
(Tech. Farm Laborer)	3,490	0
(Ag. Res. Tech I)	0	3,638
(Plant Tech. II)	755	0
(Timeslip)	640	640
Total	$26,860	$26,200

Project No: 13C-3755-8640

Title: Advanced Testing of Washington State University Raspberry Selections

Personnel: Patrick P. Moore, Associate Horticulturist, WSU Puyallup
J. Scott Cameron, Associate Horticulturist, WSU Vancouver.

Reporting Period: 1994

Accomplishments: Plantings of advanced selections were planted in 1992 at Vancouver, Puyallup, and Mt Vernon. These plants were maintained in 1993 and will be harvested in 1994.

Three growers had received plants of WSU 968 in 1992 and an additional grower received plants in 1993. Plants of WSU 908 and WSU 991 were distributed to growers in 1992. Plants of WSU 994, WSU 1017, WSU 1020, and WSU 1024 were dug from plots at WSU Puyallup and planted on fumigated ground. WSU 1017 and WSU 1020 will continue to be tested in selection trials. WSU 994 has consistently performed well, but some plants tested positive for RBDV. If virus negative plants cannot be identified, additional plants will be propagated from stock plants in the screenhouse for distribution in 1995. WSU 1024 has performed well, and should be distributed to growers for further testing. However, a double stranded RNA (dsRNA) has been detected by Bob Martin, Agriculture Canada. Investigations are currently underway to identify if the dsRNA indicates virus infections, or is of plant origin.

The possible presence of a virus was detected in WSU 991, WSU 968 and WSU 908. In virus indexing, Elzi Volk (OSU Plant Pathology) detected abnormal reactions after leaf grafting onto 'Munger' black raspberry indicator plants. These plants tested negative in ELISA tests. Bob Martin has subsequently detected a dsRNA in WSU 991. This dsRNA is different from those detected in WSU 1024. It is not known if there are planting stocks of WSU 991 without this dsRNA.

Plants of WSU 908, WSU 968, WSU 991 and WSU 994 are currently in the virus clean-up program.

Project No: 13C-3755-8640

Title: Advanced Testing of Washington State University Raspberry Selections

Personnel: Patrick P. Moore, Associate Horticulturist, WSU Puyallup
J. Scott Cameron, Associate Horticulturist, WSU Vancouver.

Year Initiated: 1994 **Current Year:** 1994 **Terminating Year:** 1997

Justification:

Developing a new raspberry cultivar is a long-term process. Promising selections are tested against standard cultivars in a replicated trial. If the selection performs well in this test, it then needs to be tested against standard cultivars in several locations throughout the region in which it will be grown. Accurate records of yield, fruit quality, susceptibility to pests at these locations is necessary in deciding to release or discard a promising selection. Many characters under genetic control are affected strongly by environment. Estimates of the effect of location on these characters will provide useful information which can improve the efficiency of a breeding program.

Selections that are grown in small test plots at research facilities may perform differently when grown in larger amounts in grower fields. Disease problems, difficulties in harvesting, or lack of suitability of the fruit for the intended use may become apparent only when suitable quantities of selections enter commercial cultivation. It is essential that promising selections be grown at several locations throughout the region by commercial growers.

Objectives:

1. To establish and maintain replicated plantings at WSU Puyallup, WSU Mt. Vernon, and WSU Vancouver of advanced selections from the Washington State University and other regional raspberry breeding programs.

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

3. Propagate an adequate number of plants of advanced selections for grower trial, distribute these plants to growers, and obtain grower reaction to advanced selections.

Procedures:

This is an ongoing project which depends on continuity of effort. Each year promising selections are propagated for possible grower trial. When several promising selections are identified, new test plantings are established.

1. Plantings established at WSU Vancouver and WSU Puyallup will be harvested for yield, fruit weight, fruit rot, and harvest season. The planting at WSU Mt. Vernon will be harvested as well, but will be funded by other sources.

2. The most promising selections identified in plantings at WSU Puyallup will be dug from field plots at Puyallup winter 1993 and planted in 1994 to produce field grown plants for distribution to growers in 1995. The highest yielding clones in the planting established in 1991 were WSU 992, WSU 1030, WSU 1031, WSU 1035 and WSU 1041. The most promising of these selections will be propagated for possible distribution 1995.

3. WSU 994, WSU 1017, WSU 1020 and WSU 1024 were field propagated for distribution to growers in 1994. WSU 994 has consistently performed well at WSU Puyallup and should be distributed to growers. However, some plants have tested positive for RBDV. If virus negative plants can be identified, then these plants will be distributed in 1994. If virus negative plants cannot be identified, additional plants will be propagated from stock plants in the screenhouse for distribution in 1994. WSU 1024 also has performed well, and should be distributed to growers for further testing. However, a double stranded RNA (dsRNA) has been detected by Bob Martin, Agriculture Canada. DsRNA usually is associated with viral infections. Investigations are currently underway to identify if the dsRNA indicates virus infections, or is of plant origin. If these plants are determined to be virus negative, then plants will be distributed to growers. If WSU 1024 is found to be virus positive, then it will be included in the heat treatment for virus elimination.

4. New plantings will be established at WSU Puyallup and WSU Vancouver. (Plantings will also be established at WSU Mt Vernon, but with different funding.) These new plantings will include WSU 994, WSU 1017, WSU 1020, and WSU 1024 if virus negative plants are available. The most promising selections from the 1991 planting will also be included as plants are available. The most promising selections from the ORUS program and the Agriculture Canada program will be included as plants are available.

5. WSU 991 will be recommended for release. However, release may be delayed until virus negative plants are identified.

Anticipated Benefits and Information Transfer:

New raspberry cultivars that are more productive or more pest resistant will be developed by this program. Such cultivars may result from crosses made this year or may already be under evaluation. The objective of this project is to make final evaluations of the most promising selections. Promising selections will be tested by commercial growers and release decisions made as rapidly as possible.

PROPOSED BUDGET:

	1993-94	1994-95
01 Timeslip labor		1,200
03 Service and supplies	800	508
04 Travel		100
07 Benefits (Timeslip)		192
Total	$800	$2,000

Current and Pending Support, 1994-95

Title of Project	Total $ Amount Requested for 1994-95	Granting source from which funding has been requested
Strawberry		
Genetic improvement of strawberry	$15,500	Washington Strawberry Commission
Development of new strawberry cultivars for the Pacific Northwest	$12,000 (anticipated request)	Oregon Strawberry Commission
Raspberry		
Red raspberry breeding, genetics and clone evaluation	$26,200	Washington Raspberry Commission
Advanced testing of Washington State University raspberry selections	$ 2,000	Washington Raspberry Commission
Development of new raspberry cultivars for the Pacific Northwest	$ 3,000 (anticipated request)	Oregon Raspberry and Blackberry Commission

Title of Project	Total $ Amount Requested for 1994-95	Granting source from which funding has been requested
Blueberry		
Evaluation of blueberries at Mount Vernon	$ 1,000	Northwest Ag Research Foundation
Evaluation of Blueberries at Mount Vernon	$ 1,000	Washington Blueberry Commission
Small Fruit Requests		
Genetic evaluation of small fruit germplasm	$10,000 (received for 1993-94)	USDA NW Center for Small Fruit Research
Evaluation of raspberry and strawberry selections	$ 6,000	Northwest Ag Research Foundation

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 L. Antonelli, Extension Entomologist, WSU-Puyallup.
Bruce D. Congdon, Associate Professor of Biology, Seattle Pacific University.

Reporting Period: 1990-1993 (termination report).

Accomplishments: We have shown that the predatory coccinnelid beetle, *Stethorus punctum picipes*, is the most important predator of spider mites in Pacific Northwest red raspberry fields. It is capable of locating very small scattered colonies of mites placed in raspberry fields where mites were otherwise scarce. *Stethorus* overwinters as adults, which become active by early April. Their excellent searching ability enables them to locate spider mites even when numbers are extremely low and keep the mite population small. The beetle has been recovered from a wide variety of non-raspberry plants and been observed to quickly repopulate raspberry fields. Therefore, in situations where a field has no *Stethorus* population because it is a new field or an old sprayed one, it can soon have a new *Stethorus* population if no insecticides are applied.

Many insecticides used to control other pests, e.g. leafrollers, root weevils, etc., kill *Stethorus*, which can result in a rapid increase in mite numbers. Malathion, used as a "clean-up" spray before harvesting raspberries with machines, may at times kill *Stethorus* but probably, by itself, has minimal effect.

The research results from the past four years give us the basis for an IPM program for spider mites on raspberries, i.e. protection of *Stethorus*. They also tell us much about the searching ability of this beetle, which was not well-understood previously.

Results:

Effect of Sprays. In 1993, the last year of this project, prebloom sprays of Guthion were applied to a block of red raspberries at each of two farms and an adjacent block remained

unsprayed. Guthion killed adult *Stethorus punctum picipes* for at least a month. There was no increase in spider mites in that time but *Stethorus* egg numbers were inexplicably higher on the sprayed plants than on unsprayed ones 3-4 weeks after treatment.

Two entire raspberry farms (including one of the above) were sprayed with Brigade (pyrethroid) just prior to harvest. At our Research Unit, two blocks were sprayed with either Brigade or Ambush (pyrethroids) and a third block was unsprayed. Mite numbers began to increase in early August. On September 29, fields receiving Brigade had 381-1031 mites per leaflet, the one with Ambush had 20 mites per leaflet, and an untreated block had 10 mites per leaflet. Both pyrethroids caused an increase in spider mites but Brigade seemed to have a more severe effect.

Early spring *Stethorus* activity. The first trap colonies were put into place on April 15 and counted on April 22 in six of the 8 study fields. Two fields lacked sufficient leaf expansion for trap colony placement. *Stethorus* was recovered in two of the six fields on an average of 1.3% of the trap colonies. In the trap colonies placed on leaves on May 6 through May 13, *Stethorus* was found in seven of the eight fields, including all six of those tested in April.
At this time *Stethorus* was present on 11.5% of the trap colonies. This was the season peak of *Stethorus* activity as measured in trap colonies. Female spider mites in the overwintering form were observed on the expanding leaves as early as April 14 in most of these fields. The earliest *Stethorus* activity apparently occurs at about the same time as leaf and spider mite emergence in red raspberry fields.

***Stethorus* dispersal into new plantings.** Trap colonies were placed into two new raspberry plantings on May 20, June 10, and July 1. Both were adjacent to established raspberry fields. In one field *Stethorus* was very active on the first two dates (found on 24 and 42% of trap colonies respectively) but absent from trap colonies on the third date. No *Stethorus* were recovered from the other field. It appears that the early season activity of *Stethorus* may include dispersal of relatively long distances. The factors preventing dispersal into the second of the two

study fields are not understood. However, *Stethorus* abundance has been low in the adjacent field in several previous years. Early season dispersal may be an important mechanism for the reestablishment of *Stethorus* following new planting, insecticide applications, or even the winter season.

***Stethorus* activity on non-raspberry vegetation.** In northwest Washington, five areas of vegetation adjacent to raspberry fields were studied. The vegetation was mostly Himalayan blackberry, but also included dewberry, salmonberry, wild rose, and alder. A total of 15 trap colony sets between April 8 and June 24 produced only eight *Stethorus* eggs and adults. In ten of the sets, no *Stethorus* were recovered. Concurrent leaf samples indicated spider mite densities were also zero during this period, but that phytoseiid mites were relatively abundant. These findings imply that raspberries and wild blackberries may harbor different predator complexes and that the non-raspberry vegetation most commonly associated with raspberry fields does not serve as a *Stethorus* reservoir.

In Clark County, trap colonies of spider mites were placed on leaves of apple, crabapple, maple, poplar, blackberries, thimbleberry, and raspberry and also on lima bean plants suspended on branches of Douglas fir trees. *Stethorus* adults and/or eggs were recovered from traps on all but thimbleberry. This shows that this predator is widely distributed and is available for quickly repopulating sprayed fields.

Publications:

Congdon, B.C., C. H. Shanks, Jr., and A. L. Antonelli. Population interaction between *Stethorus punctum picipes* (Coleoptera: Coccinellidae) and spider mites (Acari:Tetranychidae) in red raspberries at low predator and prey densities. Environ. Entomol. (In press).

C:\WINDOWS\WP51\CMS\13C2857.93 (10/8/93)

Project No.: 13C-3543-4958

Title: Control of root weevils in red raspberries.

Personnel:

Carl H. Shanks, Jr., Entomologist, WSU-Vancouver.
John D. Stark, Asst. Entomologist, WSU-Puyallup.

Reporting Period: 1993

Accomplishments:

A new insecticide was identified as being promising for control of adult root weevils. It is one which the manufacturer expects to register on food crops. A second one may be effective against weevil larvae but field trials are not completed.

Two varieties of marigold reduced numbers of weevil larvae when they were planted with strawberries. This gives us the possibility of using this plant to control weevil larvae.

Results:

Raspberries and strawberries were treated with Margosan-O (neem seed extract) in fall 1992. At 5-10 gal. per acre, numbers of root weevil larvae were reduced significantly. However, this rate is not practical and at 0.5 gal. per acre, it was ineffective.

The following insecticides were tested against adult black vine weevil (BVW) in the laboratory: Margosan-O, Confidor, Mocap, Avid, and Pirate. Only Pirate showed good activity against the weevil. Mocap and Confidor were tested against BVW larvae in the laboratory. Both gave excellent control of the larvae but, the manufacturer of Mocap has shown no interest in berry crops. A field trial with Confidor is underway.

The effect of soybean oil on activity of Asana, Brigade, and Guthion was tested. There was not enough benefit to warrant further trials. Combinations of low rates of Guthion and Asana or Brigade without oil seemed to be more efficacious than the "normal" rate of either alone.

A bait of cryolite on dried apple pomace has shown promise against BVW on cranberries in other entomologists' trials. In our laboratory trials, it killed only about 50% of the weevils in a week and appeared to be ineffective in a field trial. However, it should be retested.

When the marigolds, 'Tanji' and 'Nematicidal', were grown with 'Totem' strawberries in the pots in the greenhouse, numbers of BVW larvae were significantly reduced. It remains to be seen whether this technique can be successfully used in the field.

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Project No.: 13C-3543-4958.

Title: Control of root weevils in red raspberries.

Year Initiated: 1992 **Current Year** 1993 **Terminating Year** 1994

Personnel:

Carl H. Shanks, Jr., WSU-Vancouver.
Steven R. Booth, Research Associate, WSU-Vancouver.

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

Objectives:

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

Procedures:

Objective 1. New chemical insecticides will be tested as they become available. An example is Pirate, which is from a new class of chemical insecticide. Laboratory trials have indicated that combinations of some insecticides, by themselves only marginally effective against adult weevils, are more effective than the single chemicals alone. Combinations of such insecticides, which are currently registered on raspberries or probably will be registered, will be tested.

Biological agents include items such as entomopathogenic fungi. There are some commercially prepared fungi available for testing now and others are expected to become available. Also, soil samples from raspberry and strawberry fields will be tested for the presence of native strains of entomopathogenic fungi, especially *Metarhizium anisopliae.* If the fungus is found in samples, it will be cultured, bioassayed for virulence to weevil larvae, and the best strains will be tested in the field against root weevils.

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

Objective 2. If a material is worthy of registration on raspberries, we will cooperate with the manufacturer and IR-4 Program in obtaining registration. Such work will include providing efficacy information and treated raspberries for residue studies.

Objective 3. Potted strawberry plants will be infested with black vine weevil eggs and then the soil will be drenched with extracts of marigold roots. This will help determine whether the effect is one of toxicity to the larvae or it is repellency. Other more readily available marigold varieties will be tested also.

Field trials will be initiated. Marigolds will be interplanted with raspberries in a weevil-infested field. Data will be collected the following spring on the number of weevil larvae present.

Anticipated Benefits and Information Transfer: If chemicals such as Pirate are efficacious against root weevils in the field, they should eventually be registered for that use and give raspberry growers a new tool for controlling this pest. The research on biological control agents has the potential to result in a new generation of pest management tools which would be environmentally friendly and to which insects would be less likely to become resistant. Results of the research will be reported to the raspberry industry by talks to growers, Cooperative Extension publications, and articles in local newspapers.

BUDGET:		**1993-4**	**1994-5**
00	Salary	$ 1,932[a]	$ 0
01	Temporary worker	$ 1,000	3,000
03	Material & services	300	220
04	Travel	306	400[b]
07	Employee benefits (26% of 00)	502	0
07	Employee benefits (16% of 01)	160	480
	Total	$ 4,200	$ 4,100

[a] One month's salary for an Agricultural Research Technologist I.
[b] Travel to research plots.

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Current & Pending Support

INSTRUCTIONS:

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

Title of Project	Total $ Amount Received for 1994-95.	Granting source from which funding has been approved.
Alternative Control Strategies for Insect & Mite Pests of Small Fruits.	$41,500	USDA Northwest Center for Small Fruit Research. The largest part of this money is for a post-doctoral research associate's salary and benfits. Only a small percentage is for time-slip help. Also, this grant covers two very different research projects &, furthermore, covers cranberries, raspberries, & strawberries. About $2,000 of the proposed grant will be used to hire additional laboratory help.

Title of Project	Total $ Amount Requested for 1994-95.	Granting source to which proposal has been or will be submitted.
Control of Root Weevils in Strawberries	$4,000	Washington Strawberry Commission

PROJECT NO.: **13C-3555-5783, Termination Report**

TITLE: ACHIEVING GREATER YIELD EFFICIENCY FOR WASHINGTON RED RASPBERRY PRODUCTION

PERSONNEL: **J. Scott Cameron**, Associate Horticulturist
Chuhe Chen, **Stephen F. Klauer,** Postdoctoral Research Assoc
Paul W. Foote, **Ann Marie Smith**, **Bruce Kelley**, and
Todd Kostman, Graduate students
WSU Research and Extension Unit, Vancouver

REPORTING PERIOD: 1991-93

ACCOMPLISHMENTS:

1991

☑ Seasonal studies of photosynthesis, chlorophyll, leaf starch and yield
☑ Characterized influence of leaf position and cane fruiting status on photosynthesis

1992

☑ Seasonal studies of photosynthesis, chlorophyll, leaf starch and yield
☑ Diurnal studies of photosynthesis
☑ Preliminary radioactive labeling work.
☑ Comparisons of fruiting and deflowered cane physiology

1993

☑ Cane density study initiated and first year results are being analyzed.
☑ Across experiments, relationship of yield and cane internode length was studied.
☑ A cytokinin formulation was studied for its ability to delay leaf senescence.
☑ Radioactive labeling work undertaken to better understand growth & metabolism.
☑ Extensive literature review related to growth, development, & reproduction.

RESULTS:

1991: The gas exchange rates of leaves from fruiting (F) and deflowered (DF) canes of 'Meeker' red raspberry were compared during fruit development. Leaves on F laterals had carbon dioxide assimilation (A) rates significantly ($p<.01$) higher when green (87%) and red (22%) fruit were present, but rates of A were similar after harvest. During this time, leaves on DF laterals had greater dry weight accumulation as well as greater chlorophyll a (chl_a) and total chlorophyll (chl_t) content compared to leaves on F laterals. Accumulated attenuance and fourth-derivative spectra of leaves from F and DF canes were compared. Peak wavelengths were similar, but variation was noted in peak amplitudes.

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

1992: Assimilate demand in red raspberry leaves appears to increase during the development of green and red fruit which occurs approximately three to five weeks after anthesis. During this period, rates of photosynthesis in floricane leaves peak and drop dramatically after harvest. Total leaf chlorophyll content and ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) as a percentage of soluble protein in leaves of F plants reached a maximum at about five weeks after anthesis, while leaf starch accumulation and dry weight decreased. These results suggest that assimilate demand is greatest during the development of red fruit. Leaves on DF canes had greater chlorophyll content, dry weight, starch accumulation and thickness. Primocane leaf starch deposition characteristics were similar to floricane leaves.

Diurnal patterns for photosynthesis of red raspberry leaves are related to patterns of diurnal starch deposition in the leaf. Raspberry leaves from fruiting plants of the cultivar 'Meeker' accumulated starch during the late morning hours, followed by a decline until late afternoon when an early evening increase was followed by a decline overnight. Raspberry photosynthesis in the field was highest between 7-10 AM, lowest at 4 PM with another increase at 7 PM. Leaf starch storage patterns were not as dynamic in leaves of DF plants, and this was also reflected in a lower level of photosynthetic activity in DF leaves. Leaves from F and DF canes had similar diurnal patterns of A after harvest.

1993: Results of first year of study are still being analyzed, but as expected, yield and fruit size are a function of cane density. Densities to be increased in 1994. Analysis of data related to cane internode length indicates that shorter internodes and shorter laterals are a desirable architecture. Cytokinin formulation did not significantly delay leaf senescence or increase yield after as many as eight applications, but cool, cloudy weather may have altered developmental patterns. Radioactive labeling studies were highly successful in determining critical stages of development and competition within the plant. Aside from causing us to re-think current models of plant development, this information raises questions about the timing of floricane removal. Past assumptions made concerning plant development which were used to develop a number of important cultural practices have been inaccurate or incomplete.

PUBLICATIONS:

Cameron, J.S. 1991. Small fruit research at Washington State University Research and Extension Unit, Vancouver. Proceedings of the 1991 Annual Meeting of the NCR-22 Regional Committee for Small Fruits Research, Wooster, Ohio, Nov 22.

Cameron, J.S., Klauer, S.F., Chen, C. and P.W. Foote. 1991. The influence of cane fruiting status, leaf type, and leaf position on red raspberry photosynthesis. HortScience 26:754.

Cameron, J.S. 1992. Small fruit research at Washington State University Research and Extension Unit, Vancouver. Proceedings of the 1992 Annual Meeting of the NCR-22 Regional Committee for Small Fruits Research, Fayeteville, AK, Nov 4-7.

Klauer, S.F., C. Chen, P.F. Foote and J.S. Cameron. 1992. Diurnal photosynthesis and starch deposition in leaves of fruiting and deflowered red raspberry canes. HortScience 27:654.

Cameron, J.S. 1992. Horticultural and Physiological Research in Small Fruit Crops at The WSU R&EU, Vancouver - Research Reports (5) for the USDA-CSRS Northwest Center for Small Fruit Research Annual Meeting, Portland, OR, Nov 17-18.

Cameron, J.S. 1993. Small fruit research at Washington State University Research and Extension Unit, Vancouver. Proceedings of the 1993 Annual Meeting of the NCR-22 Regional Committee for Small Fruits Research, Kearneysville, WV, Nov 3-7.

Anderson, J. 1993. **Good Science**, Feature, ***The Vancouver Columbian***, (interview w/JSC) 06\09\93.

Cameron, J.S. Developmental and Environmental influences on the photosynthetic Biology of Red Raspberry (*Rubus idaeus* L.), Acta Hort., In Press.

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

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

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

Cameron, J. S. 1993. Raspberry productivity: Assessing the physiological costs of culture. Proc of the Conf on Setting *Rubus* Research Priorities for Canada. Ag Canada, Simcoe, Ontario, Jan 12-13, p. 28.

Cameron, J.S. 1993. The 1992 State of the Red Raspberry Plant Address. The Northwest Rasp 5(3):2.

PROJECT NO.: **13C-3555-4883, Termination Report**

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

PERSONNEL: **J. Scott Cameron**, Associate Horticulturist
Chuhe Chen, **Stephen F. Klauer,** Postdoctoral Research Assoc
Paul W. Foote, **Ann Marie Smith**, **Bruce Kelley**, and
Todd Kostman, Graduate students
WSU Research and Extension Unit, Vancouver

REPORTING PERIOD: 1991-93

ACCOMPLISHMENTS:

1991

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

1992

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

1993

☑ Influence of miticides on leaf physiology characterized at leaf & molecular levels
☑ Anatomical comparisons of susceptible and resistant\tolerant genotypes' leaves
☑ Feasibility of using $^{14}CO_2$ labeled mites to localize & monitor plant response

RESULTS:

1991: In limited mite feeding studies, and prior to visible leaf damage, photosynthesis (PN) and mesophyll conductance were negatively correlated with mite number per leaflet. After physical damage to leaves was visible, mite number per leaflet was correlated with all gas exchange parameters as well as chlorophyll (chl) content. This means that the initial depression in PN processes appears related to a response involving the biochemistry of PN. As mite numbers peak and leaves appear damaged, declines in chl content and stomatal control also depress PN. Under greenhouse conditions, PN processes were significantly depressed at mite densities suggested as thresholds for chemical control. While PN was lower in mite attacked leaves after six hours, response varied within the diurnal cycles of the plant.

The influence of miticides on PN was tested using Vendex and Kelthane in the greenhouse. Kelthane is known to have phytotoxic effects on some plants. After 1

hour, both chemicals reduced PN - Vendex by 11%, and Kelthane by 24%. After 4 hours, PN in Vendex-treated leaves recovered to control levels, while Kelthane-treated leaves were reduced by 28%. After 7 hours, Kelthane reduced PN by 36%, 20% after 24 hours, and nearly recovered to control levels after 48 hours.

1992: Single leaflets infested with mites were compared to uninfested adjacent leaflets and uninfested plants. After six days of infestation on one leaflet, PN of infested leaves was lower than that of uninfested plants. Uninfested leaflets above or below infested leaflets also had reduced PN, between that of infested leaflets and controls. Mite feeding reduced total chl and also reduced chl b relative to chl a. Analysis using fourth derivative spectroscopy revealed that two parts of the chl b spectra were damaged. The damage to these peaks reflected observed PN behavior as control leaves had normal peaks at Ca630, Cb649 and Ca693, infested leaves had severe damage to these peaks and uninfested leaves adjacent to infested leaves were intermediate in damage. This supports the hypothesis that localized mite feeding can trigger a response reducing PN throughout the plant. Identifying the level at which mite feeding initially impacts the plant is a very significant discovery.

1993: Miticide research was continued on strawberry leaves as the plants are easier to handle and are somewhat similar to raspberry. A range of miticides were tested, and a range of responses observed. Some compounds depressed PN quickly and soon recovered, while others had a delayed effect. In some cases, the influence of the chemical lasted for hours and in others for days. It also appears that certain chemicals influenced the structure and\or function of the PN apparatus.

Leaves of mite-tolerant and susceptible genotypes are being compared anatomically for any significant differences in structure which may identify factors such as physiological compensation. The Bioquant IV Image Analysis System at WSU Pullman will be used to quantify anatomical factors related to leaf physiology.

We are investigating the feasibility of using mites fed radioactive label ($^{14}CO_2$) in order to study localized and time course responses in mite feeding studies. This may help to determine the relative importance of resistance & tolerance to mites, and may also help to characterize the signaling response initiated by mite feeding.

PUBLICATIONS:

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

Cameron, J.S., C. A. Hartley, C.H. Shanks, and J.K. L. Garth. 1993. Effect of two-spotted spider mite feeding on gas exchange and chl characteristics of red raspberry leaves. In review, HortScience.

Cameron, J. S. 1993. Developmental and Environmental Biology of Red Raspberry. Sixth International Symposium on *Rubus* and *Ribes*, In press. ISHS.

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

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

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

REPORTING PERIOD: 1993

ACCOMPLISHMENTS: ***1993***

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

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

A nonchemical method (180 mph blown air) provided primocane height control at harvest equal to oxyfluorfen, but reduced yields due to lower fruit numbers. Steps will be taken to avoid flower and fruit being blown off the plant.

PUBLICATIONS:

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

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

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

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

Cameron, J. S. 1993. Developmental and Environmental Biology of Red Raspberry. Acta Hort., In press.

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

YEAR INITIATED: 1993 **CURRENT YEAR: 1993** **TERMINATING YEAR: 1995**

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

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

Kassim Al-Khatib, Assistant Weed Scientist
Carl Libbey, Research Technologist II
WSU Research and Extension Unit, Mt. Vernon

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

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

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

OBJECTIVES: **(All objectives to be addressed in 1994)**

1. Evaluate new caneburning compounds for use in Washington.
2. Collect residue and efficacy data in order to work toward the registration of promising new caneburning compounds.
3. Study possible nonchemical methods of primocane management.

PROCEDURES: Field trials established in 1993 will continue in 1994 at two sites in replicated trials with the cultivar 'Meeker'. Sites are in Clark and Skagit counties. Plots are 10' in length containing three hills trained in a modified hedgerow. Materials being tested include GOAL (oxyfluorfen), IGNITE (glufosinate), and UniRoyal C4243. At this time, all of these compounds have shown promise for cane suppression, sustainable raspberry culture and possible registration. After an observation trial in 1993, MON 13200 (Monsanto) will be dropped from further testing. All treatments are compared to an untreated control. Yield estimations are accomplished by removing and analyzing four random canes per plot just before harvest. During each week of harvest, plots are partially harvested in a random manner and the weight of 50 berries recorded. Yield potential will be estimated on both a per acre and per cane basis. At the end of the season, primocane numbers per plot will be recorded. Promising compounds will be pursued for possible registration as efficacy data is collected and residue trials will be initiated as appropriate. IR-4 Residue trials for IGNITE will be undertaken in 1994.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

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

Information \ Technology Transfer: This information will be disseminated at regional and national grower's meetings as well as through local, regional, and national publications. Newsletters and other extension and industry publications will be used to update industry on new developments as appropriate. As promising techniques and cultural practices are determined, it is our intention to work with WSU Cooperative Extension personnel to develop demonstration plots.

BUDGET:		1993-94 ALLOCATION		
Technical Salaries		Mt. Vernon		Vancouver
00	Salary (.05 FTE)	$1,500		$1,500
07	Benefits (28%)	420		420
Location Subtotal		$1,920		$1,920
		SUBTOTAL	**$3,840**	
Project Implementation				
01	Wages	$1,500		$2,200
03	Supplies and Services	750		500
04	Travel	500		-----
07	Benefits (08%)	120		176
Location Subtotal		$2,870		$2,876
		SUBTOTAL	**$5,746**	
		GRAND TOTAL A&B	**$9,586**	

BUDGET:		1994-95 REQUEST		
		Mt. Vernon		**Vancouver**
01	Wages	$3,000		$3,700
03	Supplies and Services	750		500
04	Travel	500		-----
07	Benefits (16%)	480		592
	Subtotal	$4,730		$4,792
		TOTAL	**$9,522**	

OTHER SUPPORT OF PROJECT:

Current and pending support form attached. USDA support for this project is limited to 20% of the salary of the postdoctoral research associate (Dr. C. Chen) who has major responsibility in implementing this research. This funding will not be available in 1994. Aside from USDA Special Grants such as this, this aspect of our research is one which is not easily marketed to federal and private granting agencies due to its focus on the cultivated raspberry which is considered to be a "minor" or "alternative" crop. We are attempting to include aspects of this research in grant proposals addressing basic physiological and developmental plant biology. While these types of grants may provide us with professional personnel, equipment and supplies for some of the laboratory research, the red raspberry industry is the sole end user of the applied physiology and field studies we are doing. These projects thus require industry support.

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

TITLE: **CANEBURNING MANAGEMENT AND PRIMOCANE BIOLOGY**

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

REPORTING PERIOD: 1993

ACCOMPLISHMENTS: ***1993***

☑ Monitored yield component relationships in primocane control study
☑ Monitored primocane regrowth in primocane control study
☑ Initiated study of thigmomorphogenesis for nonchemical primocane control
☑ Radioactive labeling studies for determination of intraplant competition

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

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

PUBLICATIONS:

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

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

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

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

Cameron, J. S. 1993. Developmental and Environmental Biology of Red Raspberry. Acta Hort., In press.

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

YEAR INITIATED: 1993 **CURRENT YEAR: 1993** **TERMINATING YEAR: 1995**

TITLE: **CANEBURNING MANAGEMENT AND PRIMOCANE BIOLOGY**

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

JUSTIFICATION: Primocane management is an essential aspect of raspberry culture in primocane growth patterns are a major determinant of yield. The complicated and dynamic relationships by which primocanes compete for resources, are suppressed for harvest efficiency and are then required for cropping create a very delicate balance within the raspberry plant. This critical balance and its associated relationships are still poorly understood.

The loss of dinoseb and the ensuing search for alternative caneburning chemicals has caused our research program to re-evaluate the primocane management practices of the last 30 years. We have been studying the practice of caneburning while doing research on various aspects of primocane biology and primocane suppression and their impact on yield. We have concluded that a major, fundamental change in our approach to primocane management is long overdue. The purpose of this project is to investigate alternative strategies for primocane management while gaining a better understanding of the biology of the process by which the balance between vegetative and reproductive development determines red raspberry productivity.

OBJECTIVES: **(All objectives to be addressed in 1994)**

1. Identify and evaluate changes in yield component relationships as modified by chemical caneburning.
2. Model primocane regrowth and productivity as modified by chemical caneburning.
3. Identify sources of intraplant competition through radioactive labeling.
4. Determine the role of primocane management strategies in determining optimal canopy architecture.

5. Assess ancillary benefits of caneburnng such as weed and disease control.
6. Initiate studies in nonchemical primocane management.

PROCEDURES:

Yield Component Relationships: Yield component data will be taken from chemical and nonchemical primocane management plots in order to determine those treatments which promote the most sustainable yield patterns. Data will include cane length, counting and measuring laterals per cane, and counting flowering/fruiting points. Shifts in yield component relationships related to treatment and rates will be analyzed for projected impacts on short and long-term productivity. For example, high rates of some compounds may encourage many short laterals, short internodes and larger numbers of fruit of reduced size. While this architecture is desirable and has potential for high yields, the long term health of the plants may not make this a sustainable approach. These studies have been undertaken in order to better understand the primocane suppression process and the plant's response to fruit load and compensatory relationships triggered by various primocane management regimes.

Primocane regrowth: Primocane regrowth will again be studied in northwestern and southwestern Washington. Weekly measurements of primocane length and diameter will be made in order to model the growth of primocanes as a function of primocane suppression practices. This study identifies the potential role of primocanes in yield, provides information on differences in vigor and growth rates in the two major production areas of the state, and will help to identify compounds which are "softer" on the plant. In general, as the rate of chemical applied increases, the longer the delay of primocane regrowth, and thus the next year's fruiting cane is reduced in size. This leads to a situation which has been described as **progressive decline**.

Intraplant competition: In order to most effectively manage primocanes we need to know exactly what role they play in plant productivity. A second series of studies will use $^{14}CO_2$ as a radioactive tracer to determine where the products of photosynthesis go in primocanes and floricanes during different stages of seasonal growth. This involves gassing a primocane leaf with radioactive carbon dioxide ($^{14}CO_2$) and then looking for radioactivity in other parts of the plant. In particular, the role of root growth in competing with fruit for products of photosynthesis will be further characterized. The role of root connections between floricanes and

primocanes will be investigated. We have shown that previous reports of floricanes contributing nothing after harvest are probably inaccurate, and this could factor heavily into the relationship between yield and carbohydrate reserves.

Ancillary Benefits of Caneburning: Observations will be made among various primocane management treatments for evidence of additional cultural benefits such as ancillary weed control and reduced incidence of diseases such as yellow rust.

Nonchemical Primocane Management: While chemical primocane management using herbicidal compounds is still the most effective technique known, alternative strategies must be considered. Our improved understanding of raspberry biology is helping us to find new and promising nonchemical approaches to primocane management. In 1993, a nonchemical method (180 mph blown air) provided primocane height control at harvest equal to oxyfluorfen, and this study will be expanded in 1994. It appears that some yield reduction occurred due to flowers being blown off of the plant, and steps will be taken to avoid this problem in 1994. A graduate student (TK) is investigating mechanisms of thigmomorphogenesis such as this which may be applicable for primocane control.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

Benefits: In order to effectively manage primocanes, we need to understand their role in plant development and productivity. This will not only help in screening potential compounds, but will inevitably lead to nonchemcial primocane management practices and training methods which will increase yield while safeguarding sustainable productivity. Radioactive labeling studies in 1993 have already challenged a number of major assumptions about raspberry growth and development which could radically change our approach to cultural management in the near future.

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

Project No. 13C-3761-2763

Title: Reaction of red raspberry cultivars and advanced selection to the root rot controlling fungicide Ridomil

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

Reporting Period: 3-93 to 3-94 (Final report)

Accomplishments: This project has demonstrated that the fungicide Ridomil (metalaxyl) can be used to determine the level of resistance to root rot caused by *Phytophthora fragariae* var. *rubi* in red raspberry cultivars and advanced selections. Plants treated with the fungicide were considered to be healthy plants from the stand point of root rot. Resistance in cultivars such as Cherokee and Newburgh was confirmed, however, neither was immune to the disease, as treatment with Ridomil increased the yields of both. Using Ridomil in this way has allowed us to see how much progress has been made in the breeding program in incorporating resistance into promising advanced selections. WSU 1001 was more resistant than Newburgh but was not as resistant as Cherokee. WSU 1001 is being used extensively as a parent in the breeding program. Both WSU 892 and WSU 1007 are susceptible, but they have the potential for high yield and maybe extremely productive on sites where the pathogen is not present.

Results: 1993 marked the second harvest for the experimental planting (which was planted in 1990). As in 1992, all ripe fruit was harvested by hand. Regardless of genotype yield was increased when Ridomil was used to control Phytophthora root rot. This was the case for both resistant as well as susceptible genotypes. In 1992, primocane wilting was a poor indicator of a genotypes reaction to this root disease. The cool rainy weather of early-1993, however, favored disease development and in excess of 15% of the primocanes wilted in the untreated plots of some of the susceptible genotypes. For the second year WSU 1001 was the most resistant genotype. WSU 892 had the greatest yield potential of the 12 genotypes tested. Crumbly fruit was noticed in WSU 1002, WSU 1007 and BC 8028-50 (WSU 1002 was not harvested in 1992 because of the extreme crumbliness of its fruit). Some yellow rust pustules were observed on fruit of WSU 1007.

Again in 1993 early senescence of fruiting cane leaves was recorded for untreated plants, The shift to early senescence was minimal in resistant genotypes. Primocanes of cultivars or advanced selections

with some resistance were longer and more numerous than those of susceptible ones.

Publications:

Bristow, P. R. and P. P. Moore. 1992. Reaction of red raspberry genotypes to root rot, 1991. APS Biol. and Cult. Tests. 7:6.

Bristow, P. R. and P. P. Moore. 1992. Testing red raspberry selections for resistance to Phytophthora root rot. Northeast LISA Small Fruits Newsletter. 3:12-13.

Table 1. Response of red raspberry genotypes to Ridomil, 1993 data.

Measurement	Genotype	Gram/hill Untreated	Gram/hill Treated	Untreated as % of treated
A. Yield				
	Cherokee (R)[z]	3007	3238	93
	WSU 1001 (R)	1523	3024	50
	Meeker (I)	1328	3345	40
	Newburgh (R)	1056	3332	32
	Chilliwack (I)	535	3848	14
	WSU 892 (R)	503	4068	12
	WSU 1007 (S)	201	2633	8
	WSU 1002 (R)	114	2261	5
	Tulameen (I)	149	3138	5
	Willamette (S)	151	3391	5
	Comox (S)	2	2347	<1
	BC 8028-50 (S)	0	1141	0
		Grams/fruiting cane Untreated	**Grams/fruiting cane Treated**	**Untreated as % of treated**
	Cherokee	332	291	114
	WSU 1001	225	263	85
	Meeker	362	328	110
	Newburgh	113	288	39
	Chilliwack	114	415	27
	WSU 892	60	398	15
	WSU 1007	86	310	28
	WSU 1002	62	225	27
	Tulameen	92	423	22
	Willamette	34	317	11
	Comox	1	274	<1
	BC 8028-50	0	115	0

[z] Reaction to root rot: R = resistant; I = intermediate; S = susceptible.

Project No.: 13C-3755-3775

Title: Cold Hardiness of Red Raspberry

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

Reporting Period:
This progress report covers raspberry cold hardiness research conducted during the 1992-1993 winter season.

Accomplishments:

Cold hardiness of stems and buds of 12 named red raspberry cultivars (Brandywine, Canby, Chilcotin, Chilliwack, Cuthbert, Krupna Dvorda, Latham, Meeker, Puyallup, Schonemann, Viking, Willamette) and 2 numbered selections (WSU 994, and WSU 1076) was tested on Nov 16, 1992, Jan 19 and Mar 16, 1993. Cold hardiness of two-bud cane sections from 3 plants of each genotype growing in the field at WSU Farm 5 was determined in controlled laboratory freezing tests as described in the procedures section of this proposal. A Tk_{50}, defined as the temperature at which 50% freeze damage occurred, was calculated for the buds and stem of each cane section.

Results of the Nov 16, Jan 19 and March 16, freezing tests are shown in Tables 1, 2 and 3, respectively. WSU 994 is a high yielding selection from the WSU breeding program that performed very well in the 1992-1992 freezing tests and is again one of the hardiest cultivars in Nov and Jan. Although Krupna Dvorda was the least hardy cultivar in the Nov freeze test, it was among the hardiest cultivars in Jan and was moderately hardy in Mar. Nov results for Krupna Dvorda may be due to mechanical and insect damage to cane samples. This cultivar should be retested before a conclusion can be drawn concerning its rate of cold acclimation.

As in past freezing tests, raspberry buds were less hardy than stems. This difference in hardiness was greatest in the Mar freezing test when the primary buds of many of the cultivars had initiated growth. In Nov and Jan, the vascular tissue at the base of the primary bud was less hardy than the leaf primordia inside the bud. However, by Mar the situation was reversed with the vascular tissue in the bud base being more cold hardy than the leaf tissue. Differential growth of the primary buds before the freeze may account for the variable response of buds to temperatures in the Mar freeze.

Publications:

1. Hummel, R. L. 1993. Reflections on raspberry winter damage: Whatcom County 1992-1993. Berry Basket Newsletter. July. pp. 4-5.

2. Bristow, P. R. and R. L. Hummel. 1993. Response of red raspberry to root rot and Ridomil. Proc. Western Washington Horticultural Association. 83:102-105.

3. Hummel, R. L., P. R. Bristow, J. S. Cameron, and P. P. Moore. 1992. Cold hardiness physiology and yield of small fruit crops in western Washington and Oregon as influenced by climate, genetic and pathological factors. Proc. Northwest Center for Small Fruit Research. 1:34.

4. Bristow, P. R. and R. L. Hummel. 1993. Effect of *Phytophthora fragariae* var. *rubi* on yield components and cold hardiness of red raspberry. Acta Horticulturae (In press).

5. Moore, P. P., R. L. Hummel, and P. R. Bristow. 1993. Strawberry cold protection using floating row covers. Acta Horticulturae (In press).

6. Yost, R. 1993. Coming to grips with root rot. Pacific Farmer-Stockman. 118(2):6. Information provided for this article (Bristow & Hummel).

7. Mullen, L. 1993. Winter cast chill on raspberries. Bellingham Herald. May 21, 1993. page 1. Information provided for this article (Hummel and MacConnell).

8. Hummel, R. L. and P. P. Moore. 1992. Cold hardiness of red raspberry. pp. 15-20. In 1993 Red Raspberry Research Proposals & 1992 Progress Reports. A. D. Davison (editor). 54 pp.

9. W-130 "Freezing Damage and Protection of Fruit and Nut Crops" contributed to the revision of this project.

Table 1. Cold hardiness of red raspberry cultivars collected from the field November 16, 1992.

Cultivar	Bud Tk_{50}[z] °F (°C)	Stem Tk_{50} °F (°C)
Krupna Dvorda	8.6 (-13.0) a[y]	8.2 (-13.2) a
Cuthbert	7.9 (-13.4) a	7.5 (-13.6) ab
Willamette	6.3 (-14.3) ab	4.1 (-15.5) abc
WSU 1076	6.1 (-14.4) ab	2.7 (-16.3) abcd
Puyallup	4.8 (-15.1) abc	4.0 (-15.6) abc
Chilcotin	3.0 (-16.1) bcd	1.6 (-16.9) cd
Meeker	2.7 (-16.3) bcd	2.1 (-16.6) bcd
Chilliwack	1.6 (-16.9) cd	0.0 (-17.8) cde
Brandywine	1.4 (-17.0) cd	0.3 (-17.6) cd
WSU 994	1.4 (-17.0) cd	-0.9 (-18.3) cdef
Canby	1.0 (-17.2) cd	-0.8 (-18.2) cdef
Schonemann	-0.9 (-18.3) de	-2.6 (-19.2) def
Latham	-3.8 (-19.9) e	-6.2 (-21.2) f
Viking	-4.2 (-20.1) e	-5.6 (-20.9) ef

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

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

Table 2. Cold hardiness of red raspberry cultivars collected from the field January 19, 1993.

Cultivar	Bud Tk_{50}[z] °F (°C)	Stem Tk_{50} °F (°C)
WSU 1076	-6.5 (-21.4) a[y]	-9.8 (-23.2) a
Puyallup	-6.5 (-21.4) a	-12.3 (-24.6) abc
Willamette	-9.0 (-22.8) ab	-11.7 (-24.3) abc
Meeker	-9.2 (-22.9) ab	-11.4 (-24.1) ab
Cuthbert	-9.9 (-23.3) abc	-12.8 (-24.9) abcd
Canby	-12.8 (-24.9) bcd	-15.2 (-26.2) bcdef
Chilcotin	-13.1 (-25.1) bcd	-13.4 (-25.2) abcde
Schonemann	-13.9 (-25.5) cde	-18.8 (-28.2) f[x]
Chilliwack	-14.3 (-25.7) cde	-16.8 (-27.1) cdef
Krupna Dvorda	-14.8 (-26.0) de	-18.0 (-27.8) def[x]
Latham	-16.1 (-26.7) de	-18.4 (-28.0) ef
WSU 994	-16.2 (-26.8) de	-17.9 (-27.7) def[x]
Brandywine	-16.8 (-27.1) de	-18.2 (-27.9) ef[x]
Viking	-17.9 (-27.7) e[x]	-18.9 (-28.3) f[x]

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

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

[x] One or more samples of this cultivar and tissue type did not reach the 50% damage level at the lowest freeze test temperature of -18.4°F (-28.0°C).

Table 3. Cold hardiness of red raspberry cultivars collected from the field March 16, 1993.

Cultivar	Bud Tk_{50}[z] °F (°C)	Stem Tk_{50} °F (°C)
Latham	17.1 (-8.3) a[y]	-2.6 (-19.2) ab[x]
Chilcotin	13.8 (-10.1) ab	-3.6 (-19.8) ab[x]
WSU 1076	13.6 (-10.2) ab	3.6 (-15.8) a
Chilliwack	12.7 (-10.7) abc	-0.2 (-17.9) ab[x]
WSU 994	11.7 (-11.3) abcd	0.7 (-17.4) ab
Puyallup	9.5 (-12.5) abcde	-0.8 (-18.2) ab
Canby	8.1 (-13.3) abcde	-1.7 (-18.7) ab
Krupna Dvorda	7.5 (-13.6) abcde	-0.4 (-18.0) ab
Viking	6.8 (-14.0) bcde	-5.4 (-20.8) b[x]
Brandywine	3.4 (-15.9) cde	-5.3 (-20.7) b[x]
Willamette	3.4 (-15.9) cde	0.1 (-17.7) ab[x]
Schonemann	3.4 (-15.9) cde	-4.5 (-20.3) b[x]
Meeker	2.3 (-16.5) de	-4.5 (-20.3) b[x]
Cuthbert	1.6 (-16.9) e	-0.9 (-18.3) ab

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

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

[x] One or more samples of this cultivar and tissue type did not reach the 50% damage level at the lowest freeze test temperature of -18.4°F (-28.0°C).

Project No.: 13C-3755-3775

Title: Cold Hardiness of Red Raspberry

Year Initiated 1988-1989 Current Year 1993-1994 Terminating Year 1994

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

Justification:

Crop loss due to cold damage is a recurring problem for 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 detected in Washington red raspberry plantings. Again in 1993, significant crop loss due to winter damage was reported by growers in Whatcom County.

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

The focus of this project is the cold hardiness evaluation of red raspberry genotypes of interest to the breeding program conducted by Dr. Patrick Moore at WSU Puyallup. To the best of our knowledge, the small fruit cold hardiness research projects being conducted in Idaho and Oregon are different. In Idaho, cold hardiness of red raspberry stems is being tested. The Idaho climate conditions and cultivars are not the same as in western Washington and we are testing both bud and stem cold hardiness. In Oregon, researchers are concentrating their efforts on testing cold hardiness of black berries rather than red raspberries.

Objectives:

1. Identify cold hardy *Rubus* genotypes of potential importance to the breeding program.

2. Measure the seasonal change in cold hardiness of buds and stems of field-grown *Rubus* genotypes.

Procedures:

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

Freezing tolerance of stems and buds of red raspberry cultivars and selections important in the breeding program will be tested in November 1993, January and March 1994. On each freezing test date, a single cane will be cut from 3 hills of each clone growing in the field at WSU farm 5 near Puyallup, Washington. Canes will be taken to the laboratory, cut into two-bud segments after the terminal six to eight buds have been discarded, and placed in contact with a moist paper towel in wide-mouth polyethylene tubes. Tubes will be immersed a polyethylene glycol bath at 0°C (32°F), and crushed ice will be added to each tube to initiate ice nucleation and freezing of stems. The bath temperature will be decreased to -2°C (28.4°F) where it will be held overnight (about 14 hours), and then lowered at the rate of 3°C (5.5°F)/hour. Samples will be removed at successively lower 2°C (3.3°F) temperature intervals.

After freezing, samples will be thawed overnight in a refrigerator, removed from the tubes, placed with a moist paper towel in polyethylene bags, and incubated at room temperature and 100% relative humidity for 10 to 14 days. Control samples of each clone will be placed directly into a polyethylene bag and incubated without freezing. After incubation, sample viability will be determined by dissecting and visually evaluating stems and buds for tissue injury with the aid of a dissecting microscope. Stems and buds showing brown discoloration and breakdown of cells in the cambium and phloem will be rated as dead. Uninjured tissues will remain green. The percentage of stems and buds surviving each temperature will be

recorded. From these data, a Tk_{50}, the temperature where 50% damage occurred, can be determined for buds and stems of each raspberry cane on each freezing test date.

The goal of this project is to identify existing cultivars and develop new cultivars that growers can use to minimize the impact of cold damage on the red raspberry crop. Results of this research will be transferred to growers in Raspberry Commission reports, in talks given at the Western Washington Horticultural Association and in papers published in the WWHA Proceedings. In addition, articles can be written for the "Berry Basket" and/or the "Northwest Raspberry" publications.

Budget:

	Current 1993	Proposed 1994
Salaries Laboratory Technician I (at 0.15 FTE)	$3,420	$3,694
Operations	100	100
Employee Benefits	927	1,002
TOTAL	$4,447	$4,796

PRIMOCANE FRUITING RASPBERRY SUMMARY NOTES - 1993 - Hugh Daubeny, October 27, 1993

I have highlighted the cultivars and selections which are of particular interest at this time. The outstanding performer was East Malling (EM) 5961/24. First harvest was July 30 and last harvest was October 25. This contrasts dramatically with Autumn Bliss - first harvest August 9 in one plot and August 16 in the other; last harvest in both plots was September 27. Autumn Bliss has been the early standard. Incidence of fruit rot for Autumn Bliss is unduly high since several harvest dates were missed in September. Dinkum, which has attracted considerable attention because of its excellent, raspberry-like flavor, was first harvested August 16; harvest was completed October 10. First harvest date for Heritage in all 3 plots was August 26 and last harvest date was either October 15 or October 7.

EM 5961/24, a second backcross derivative of Rubus spectabilis (salmonberry) produced large fruit and had the highest early yield and the highest cumulative yield of any cultivar or selection. Overall, fruit quality is acceptable, flavor is superior to Heritage but not as pleasant as Dinkum and color is not quite as bright or glossy as Heritage but comparable to both Dinkum and Autumn Bliss. I have asked Vicky Knight at Horticulture Research International, East Malling if the selection can be more widely tested in the Pacific Northwest.

Among other selections, Polana produced a relatively high yield but fruit was small and soft. The plant stand of the selection was relatively poor and this may have affected its performance. The cultivar is attracting wide interest in Europe. I plan to re-propagate and subsequently re-evaluate it. EM 3676/6 will be named Malling Britten for Ontario conditions. In August, under cool and damp conditions, it was relatively difficult to harvest and this may have contributed to the relatively high incidence of fruit rot. Size and appearance are good. I still do not think the selection (cultivar) is adapted to Pacific Northwest conditions; moreover, its ripening season offers no advantages over the cultivars now or soon to be available. Bogong (Autumn Bliss x Comox) is newly released from the Australian breeding program. It is not particularly early and yield was not high. Fruit quality was superior to Heritage and comparable to Dinkum. However, I cannot see, at this time, that the selection will have a place in British Columbia. Elsewhere in the Pacific Northwest it may be earlier. It does show concentrated ripening compared to some of the other cultivars or selections.

It is planned to continue to evaluate single plots of all the cultivars and selections. Red River, from the Ag Canada Research Station at Morden, Manitoba was planted in 1992 but made poor growth and will be re-propagated and planted with Polana and the standards in 1994.

PRIMOCANE FRUITING RASPBERRY SUMMARY 1993

		Summary to August 31				First harvest to final harvest						
Cultivar	First Harvest Date	Total Yield (g/c)	Rot (%)	Market Yield (g/c)	Size Index (g/f)	Total Yield (g/c)	Rot (%)	Market Yield (g/c)	Size Index (g/f)	Index Range (g/f)	Final Harvest Date	Harvest Ease*
AMITY 1989 planting	8/16	27	28.9	19	3.4	84	11.8	74	2.7	1.9-4.1	9/30	2-3
AMITY 1990 planting	8/16	26	32.9	17	3.3	100	12.1	88	2.4	0.5-3.6	10/7	2-3
AUTUMN BLISS 1990 planting	8/9	49	34.0	32	3.7	71	31.1	49	2.9	1.4-4.7	9/27	3-5
AUTUMN BLISS 1991 planting	8/16	28	39.2	17	2.4	50	24.6	38	1.9	1.2-2.8	9/27	3-5
DINKUM	8/16	35	10.2	31	3.7	161	3.7	155	2.9	1.9-4.1	10/7	4-5
HERITAGE 1989 planting	8/26	8	10.6	7	2.5	143	4.2	137	2.1	1.4-2.7	10/15	4-5
HERITAGE 1990 planting	8/26	3	21.1	2	2.4	85	3.6	82	1.9	1.3-2.6	10/15	4-5
HERITAGE 1991 planting	8/26	2	4.5	2	1.7	101	2.3	99	1.5	1.2-2.3	10/7	4-5
LJULIN	8/16	16	41.1	10	2.6	80	11.3	71	2.0	1.3-3.3	9/27	
M. CASCADE	8/4	46	14.5	39	3.7	138	8.3	127	2.9	1.6-4.7	9/30	4-5
POLANA	8/9	173	22.4	134	2.6	226	17.4	187	2.1	1.1-3.7	9/13	
REDWING	8/30	1.1	28.3	0.8	1.9	31	16.2	26	2.6	1.9-3.5	9/13	3
RUBY 1989 planting	8/23	11	41.7	7	3.5	214	15.1	181	3.2	1.8-5.1	10/15	2-3
RUBY 1990 planting	8/19	3	76.6	0.7	3.1	64	11.8	56	2.6	1.4-4.1	10/7	
SUMMIT	8/12	20	49.2	10	3.1	63	19.7	50	2.3	1.3-4.1	9/27	3-4
A83-31-B5	8/30	4	0	4	4.4	113	4.5	108	2.8	1.7-4.3	10/18	3-4
A85-24-A7 (BOGONG)	8/23	26	18.9	21	4.0	90	6.7	84	2.6	1.6-4.8	9/30	4-5
A85-24-B6	8/26	3	3.7	3	3.0	53	3.2	51	2.3	1.3-3.1	9/30	
A85-24-B7	8/23	30	20.9	24	4.1	171	5.9	161	3.0	1.9-4.4	10/7	
EM 3676/6	8/16	33	38.9	20	4.2	163	11.3	145	3.3	2.2-4.7	10/7	2-4
EM 5602/13	7/30	98	12.8	85	3.4	152	10.9	136	3.2	2.5-4.9	9/13	
EM 5605/12	8/16	25	29.8	18	3.8	127	7.8	117	3.0	2.1-4.6	10/7	
EM 5961/24	7/30	161	18.8	131	3.9	486	10.4	436	3.1	1.9-5.0	10/25	4-5
EM 5965/68	7/30	97	16.1	82	3.2	180	10.5	161	2.6	1.6-4.0	10/7	
EM 5967/57	8/4	37	27.0	27	3.0	146	8.5	134	2.5	1.8-3.6	10/7	
EM 6215/30	8/6	65	29.9	46	3.0	85	23.1	65	2.8	1.7-3.9	9/2	
EM 6216/25	8/16	40	37.6	25	2.0	58	25.9	43	1.7	1.0-2.7	9/9	
EM 6300/105	7/30	56	56.0	25	3.4	153	28.5	110	3.0	1.6-4.8	9/27	
POLAND 81265	7/30	101	22.5	78	3.1	142	17.1	118	2.8	1.2-5.1	9/9	

g/c = grams per cane
g/f = grams per fruit averaged from fifty-fruit samples over the season
* Ratings for ease of harvest: 1=difficult, 5=easy

-based on yield of 18 canes (3 stools with 6 canes each)

	Total yield (kg)	Market yield (kg)	% Rot, mostly Botr	Size Index (g)	Size Index Range(g)	First Harv. Date	50% Harv. Date	Sn max (d)	Sn avg (d)	Yld (t/ ha)	Yld (T/ ac)
1990 Trial											
CHILCOTIN	10.0 bc	9.9 bc	1.39 a-d	2.84 fg	2.1-3.7	06-10	06-30	40	38 def	14.4	6.4
CHILLIWACK	9.9 bc	9.8 bc	0.77 cd	2.83 fg	1.8-3.8	06-15	07-02	35	34 ef	14.2	6.3
COMOX	14.9 a	14.7 a	1.68 a-d	3.46 bc	2.3-4.6	06-10	07-08	47	44 bc	21.4	9.6
MEEKER	13.0 ab	13.0 ab	0.48 d	2.95 ef	2.1-4.7	06-18	07-09	42	36 def	18.7	8.4
SKEENA	12.7 ab	12.7 ab	0.42 d	2.87 fg	1.9-3.7	06-10	06-30	36	35 ef	18.2	8.1
TULAMEEN	12.3 ab	12.0 ab	2.21 a	4.24 a	3.1-5.6	06-15	07-05	42	39 cde	17.6	7.9
WILLAMETTE	9.4 bc	9.2 bc	1.13 a-d	2.76 fg	2.1-3.5	06-10	06-30	36	35 def	13.4	6.0
83-16-50	14.4 a	14.3 a	0.86 bcd	3.66 b	2.4-5.0	06-10	07-04	43	42 bcd	20.7	9.2
86-1-15	9.8 bc	9.6 bc	2.07 ab	3.03 def	2.2-3.8	06-10	06-28	36	36 def	14.0	6.3
86-6-15	11.3 ab	11.2 ab	0.70 cd	3.39 bcd	2.7-4.7	06-10	07-03	40	36 def	16.2	7.2
86-7-21	15.0 a	14.8 a	1.31 a-d	2.93 ef	2.3-3.8	06-10	07-13	55	52 a	21.6	9.6
86-17-25	9.2 bc	9.1 bc	1.30 a-d	3.27 cde	1.9-4.3	06-10	07-08	47	38 de	13.2	5.9
86-17-69	11.5 ab	11.3 ab	1.83 abc	2.72 fg	1.9-4.0	06-10	07-10	47	46 b	16.5	7.3
86-42-1	6.2 c	6.1 c	1.05 a-d	3.27 cde	2.6-3.9	06-15	07-02	35	32 f	8.8	3.9
86-42-40	9.2 bc	9.0 bc	1.46 a-d	2.50 g	1.7-3.2	06-10	06-28	36	35 def	13.1	5.9
1989 Trial											
MEEKER	12.2 ab	12.0 ab	1.55 -	3.40 c	2.1-4.9	06-22	07-09	31	31 ab	17.5	7.8
85-1-13	8.7 c	8.6 c	1.10 -	2.92 d	2.0-3.9	06-10	07-05	43	37 a	12.5	5.6
85-1-36	11.1 bc	11.0 bc	1.64 -	3.29 cd	2.3-4.5	06-15	07-01	38	34 ab	16.0	7.1
85-5-24	13.3 ab	12.9 ab	2.39 -	4.63 a	3.0-5.6	06-15	07-04	35	30 bc	19.1	8.5
85-10-55	8.2 c	8.1 c	1.72 -	3.94 b	2.0-5.6	06-22	07-05	28	26 c	11.8	5.3
85-12-18	10.1 bc	10.0 bc	1.46 -	4.36 a	3.1-6.2	06-22	07-06	31	29 bc	14.5	6.5
85-18-16	14.9 a	14.6 a	1.73 -	3.29 cd	2.1-4.6	06-22	07-09	35	33 ab	21.3	9.5
1988 Trial											
MEEKER	11.1 -	11.1 -	0.46 -	3.13 c	2.2-4.3	06-22	07-09	31	31 c	16.0	7.1
81-12-23	13.1 -	12.9 -	1.61 -	3.63 b	2.8-5.3	06-10	07-04	43	39 a	18.8	8.4
83-16-28	10.6 -	10.4 -	1.49 -	3.69 b	2.9-4.5	06-10	06-27	36	33 bc	15.2	6.8
83-16-50	12.2 -	12.0 -	1.67 -	4.21 a	2.2-5.6	06-15	07-05	38	34 abc	17.5	7.8
83-16-59	12.6 -	12.5 -	0.90 -	3.41 bc	2.3-4.9	06-15	07-05	38	34 abc	18.1	8.1
84-12-22	12.2 -	12.0 -	2.17 -	3.47 bc	2.2-5.5	06-15	07-06	42	39 bc	17.5	7.8
1987 Trial											
MEEKER	13.5 -	13.5 -	0.17 -	3.20 b	2.0-4.5	06-22	07-06	35	33 -	19.4	8.6
83-16-2	9.3 -	9.3 -	0.52 -	4.03 a	2.6-5.6	06-18	07-03	28	27 -	13.4	6.0
83-16-35	12.2 -	12.2 -	0.52 -	4.20 a	2.8-5.6	06-15	07-05	42	34 -	17.6	7.9

Raspberry Shelf-life 1992

June 22	0hrs	24hrs	48hrs	72hrs	96hrs	120hrs	TOTAL
CHILLIWACK		8.3 ab	8.3 ab	7.0 a			56.7 ab
COMOX		8.0 b	8.0 ab	6.7 a			54.3 bc
SKEENA		7.0 c	6.3 c	6.0 ab			52.3 cde
TULAMEEN		8.3 ab	8.3 ab	6.7 a			54.0 c
83-16-28		7.0 c	7.0 bc	5.3 b			51.0 e
83-16-50		7.0 c	7.0 bc	6.0 ab			51.3 de
85-1-36		8.0 b	7.7 abc	6.6 a			53.7 cd
85-5-24		9.0 a	8.7 a	6.3 ab			58.0 a
June 25							
CHILLIWACK		8.0 ab			8.0 a	7.0 bc	55.3 ab
COMOX		8.0 ab			7.0 bc	7.0 bc	54.0 abc
MEEKER		7.3 bc			7.0 bc	6.0 de	51.7 bcde
SKEENA		5.7 ef			5.7 efg	6.0 de	48.0 ef
83-16-2		6.3 de			6.0 def	5.0 f	49.3 def
83-16-35		5.3 f			5.0 g	6.0 de	46.0 f
83-16-50		6.0 def			5.7 efg	5.0 f	48.3 ef
85-1-13		7.7 b			6.7 bcd	6.7 cd	54.0 abc
85-1-36		6.7 cd			7.0 bc	7.0 bc	51.3 cde
85-5-24		7.7 b			7.3 ab	7.7 ab	53.0 bcd
85-10-55		8.0 ab			7.0 bc	6.7 cd	54.0 abc
85-12-18		6.0 def			5.3 fg	5.0 f	48.0 ef
85-18-16		8.7 a			8.0 a	8.0 a	57.0 a
86-1-54		6.7 cd			6.7 bcd	5.7 ef	52.7 bcd
86-6-15		6.7 cd			6.3 cde	6.3 cde	51.0 cde
July 3							
CHILLIWACK	7.3 bcd			7.0 c			53.0 abc
COMOX	7.0 cd			7.0 c			48.7 c
MEEKER	6.7 de			6.7 c			50.0 bc
TULAMEEN	7.7 bc			7.3 bc			51.0 abc
83-16-50	6.0 e			6.7 c			48.7 c
85-1-13	7.3 bcd			7.0 c			53.3 abc
85-1-36	8.0 ab			8.0 ab			54.7 ab
85-5-24	8.7 a			8.0 ab			54.7 ab
85-10-55	8.0 ab			7.3 bc			54.3 ab
85-12-18	7.0 cd			8.0 ab			50.3 bc
85-18-16	8.0 ab			8.7 a			55.3 a

Firmness and Soluble Solids 1992

	Firmness (N)	% Soluble Solids
CHILLIWACK	1.94 ab	12.18 a
MEEKER	1.52 b	11.29 ab
TULAMEEN	2.31 a	11.96 ab
83-16-50	1.79 ab	10.82 bc
85-1-36	1.92 ab	11.00 abc
85-5-24	2.38 a	9.88 cd
85-18-16	2.15 a	9.14 d
86-6-15	1.90 ab	8.88 d

Project No:

Title: Raspberry breeding and variety development in conjunction with the B.C. raspberry breeding program.

Year Initiated: 1959 **Current Year:** 1993-1994 **Terminating Year:** Indefinite

Personnel: Hugh Daubeny

Justification:

- To develop better adapted pest resistant red raspberry varieties for the Pacific Northwest and to develop germplasm for future use in raspberry breeding programs.

- Raspberries are grown throughout the Pacific Northwest and improved varieties should be produced that are adapted to conditions in Oregon and also in Idaho where winter hardiness is a prime concern. Selections made in B.C. are often hardy enough to withstand conditions in Idaho.

Objectives:

- To continue evaluation of all variety selections in test plots at the Vancouver Research Station. These include four selections from the B.C. breeding program that are now into the certified propagation scheme. Of these, 83-16-50 is now into large scale growers tests and indications, to date, are that it will probably be named within the next two years. Plants of the other selections should be available for grower trails in 1994 and/or 1995. In 1994 evaluations in the test plots will include yield and fruit quality determinations and also reactions to various pests and diseases, including fruit rot, cane disorders, aphids (which vector the mosaic virus complex) and raspberry bushy dwarf virus. Any winter damage will be recorded relative to the standard cultivars, Meeker, Chilliwack and Tulameen. Evaluations will also involve primocane fruiting varieties from other programs.

Procedures:

- Procedures will involve harvesting of sound and rotted fruit, fruit firmness determinations with a pressure gauge, postharvest rot screening, soluble solid and acidity determinations, evaluation of frozen samples, observations of various pests and diseases under field conditions and using the ELISA procedure to determine if raspberry bushy dwarf virus is present.

Anticipated Benefits and Information Transfer:

- The results of the evaluations will be directly available to the red raspberry industries and will determine which selections will be further propagated for potential variety status.

Budget:

- I am requesting $10,000 to support two plant science students at a pay rate of $10.00 (Canadian) per hour. This amount will support two students for approximately 4 months during the growing season. This includes all benefits and will be administered by the B.C. Blueberry Co-operative Association, 31852 Marshall Road, Abbotsford, BC, V2S 4N5.

- At present I do not know what other funding support the program will receive but anticipate some funds from the Lower Mainland Horticultural Improvement Association and the B.C. Raspberry Growers Association.

PROGRESS REPORT WA RED RASPBERRY COMMISSION

Title: Improving machine harvest efficiency of red raspberries

Personnel: Dr. Bernadine C. Strik, Associate Professor,Department of Horticulture, Oregon State University, Ag & Life Sciences 4017, Corvallis, OR 97331-7304
Mr. Joe DeFrancesco, Mr. Neil Bell, and Ms. Helen Cahn, Research Assistants

Reporting Period: 1993-94

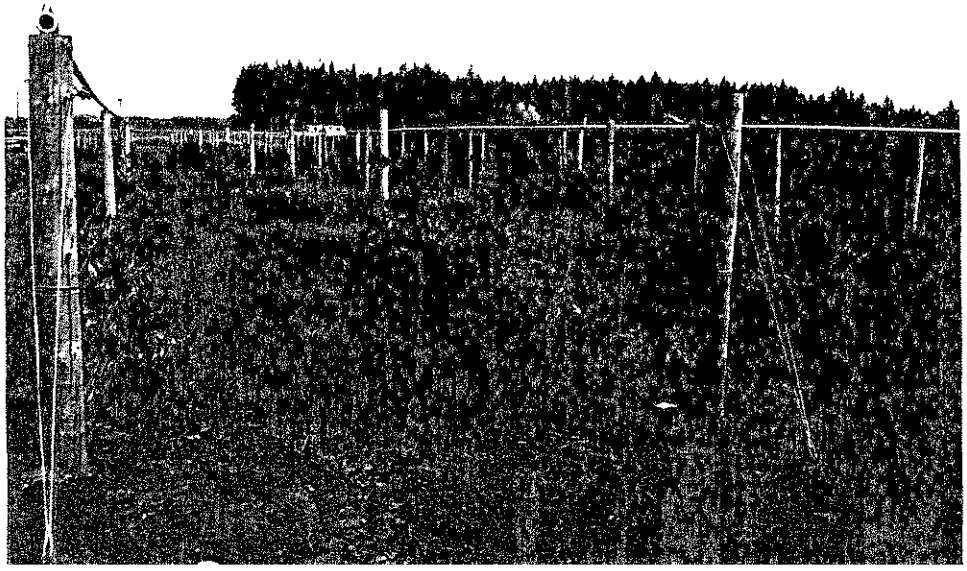
Accomplishments/Results:

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

A field trial of 'Meeker' was established at the North Willamette Research and Extension Center (NWREC) in spring, 1993.

The experiment consists of 8 treatments and 4 replicates arranged in a completely randomized design. The 8 treatments are as follows: **Hill system: A**) canes topped at 6' (5 canes/hill; cane density .2/ft^2); **B**) canes topped at 6' (10 canes/hill; cane density .4/ft^2); **C**) canes topped at 6' (15 canes/hill; cane density .6/ft^2); **D**) untopped, looped bundles (cane no.= A); **E**) untopped, looped bundles (cane no.= B); **F**) untopped, looped bundles (cane no.= C); **Hedgerow: G**) topped at 6' (6" wide); **H**) topped at 6' (1' wide). Treatments A through F were planted at a spacing of 2.5' x 10' and G and H at 2' x 10'. (note that these spacings were changed from the 1993-94 proposal to better reflect trends in the industry). Each of the 32 plots consists of a 20' row of plants with a 10' un-planted section on either side. The planting is thus ½ acre in size including guard rows and headland space (Fig. 1).

Figure 1. Machine harvest efficiency planting of 'Meeker', NWREC (photo, 10/27/93)



PROPOSAL: WA RED RASPBERRY COMMISSION--1994-95

Title: Improving machine harvest efficiency of red raspberries

Year initiated: 1993; **Current Year:** 1994; **Terminating Year:** 1997

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

Mr. Joe DeFrancesco, Mr. Neil Bell, and Ms. Helen Cahn, Research Assistants

Justification:

The Pacific Northwest (OR and WA) is the leading producer of red rasbperries in the United States with 63 million pounds produced from 9,300 acres in 1992. Over 75% of the red raspberries produced in the Pacific Northwest are machine harvested. Machine harvest is more economical for the grower and produces a better product for processing with better color and higher soluble solids than hand picking.

Average yields of red raspberry in Oregon and Washington are 3.3 tons/acre. This is estimated to be less than **one fourth** of the potential yield that could be achieved through modified cultural practices and increased machine harvest efficiency. Currently about 20 to 25% of the crop is estimated to be lost on the ground during machine harvest. If yield and machine harvest efficiency could be improved through modified cultural practices, the red raspberry industry could have additional production of at least 5 tons/acre.

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

Essentially all red raspberries in the Pacific Northwest are produced in a hill system with plants grown as individual clumps of canes. Plants are set 2' apart in rows spaced 10' to accommodate machine harvesters. Growers often thin out canes in each hill at pruning time. The method by which growers train the canes on the trellis is either a bundle with the canes topped at about 6' or looped bundles with the canes un-topped.

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

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

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

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

Objectives:

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

This funding year we plan to maintain the planting and train primocanes as they grow; first harvest will be in 1995.

Procedures:

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

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

Treatments A through F were planted at a spacing of 2.5' x 10' and G and H at 2' x 10'. (note that these spacings were changed from the 1993-94 proposal to better reflect trends in the industry).

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

In 1994, the primocanes will be trained as they grow to form the hills or hedgerow. In winter 1994, the plots will be pruned to the desired cane density.

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

Data collected at the end of fruit harvest per 5 canes in each plot: number of nodes/cane; number of reproductive nodes/cane (calculate bud break); average lateral length; number of fruit per lateral; cane length (looped bundles only); and cane diameter. Data collected per 2 ft^2 section of row: number of canes.

Records of the labor hours required to prune and train the plots will be kept.

Anticipated Benefits:

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

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

Budget:

Support in 1993-94: $2,040

Request for 1994-95:

Temporary Labor	$500
8% OPE	40
TOTAL	
	$540

Other Support to Project:

TITLE:	TOTAL $, 1993-94	TOTAL REQUESTED, 1994-95
Machine harvest effic. raspb.	$2,040--WA RRC	$540--WA RRC
"	$3,500--ORBC*	$1,000--ORBC*

* Part of larger funded proposal to support research assistant salary

10/28/93

Bernadine C. Strik, Associate Professor, Horticulture

Title: DEVELOPMENT OF REGENERATION AND TRANSFORMATION PROTOCOLS FOR RASPBERRY AND ENGINEERING OF VIRUS RESISTANCE AND HERBICIDE TOLERANCE.

Personnel: Robert R. Martin, Research Scientist; Kirsten Finstad and Morven McLean, PostDoctoral Research Associates; Agriculture Canada Research Station, 6660 NW Marine Dr. Vancouver, B.C. V6T 1X2

Reporting Period: 1993

Accomplishments: Sequence of raspberry bushy dwarf virus coat protein has been completed. Seven varieties of raspberries are established in tissue culture. Regeneration of Canbe has been accomplished, Skeena in very low numbers has also been regenerated.

Results: Five local varieties and two foreign varieties of raspberry are presently being maintained in the greenhouse and micropropagated *in vitro*. Four different published and/or recommended media have been tested for micropropagation. While improvements have been made and growth rates are now acceptable, it is felt that continued optimization of the micropropagation protocol can enhance the vigour of *in vitro* raspberry plantlets. *In vitro* plantlets are a preferred source of leaf material for shoot regeneration of raspberry, demonstrated by this study as well as others.

Shoot regeneration has been achieved in the two foreign varieties, Comet and Canby. The level of regeneration is dependent on the quality of the donor leaf material, the presence of various vitamins and other organic media additives, and the choice of cytokinin, thidiazuron being by far the most effective of those tested. Of five local varieties being studied (Chilliwack, Meeker, Skeena, Tulameen and Willamette) only Skeena has shown any regeneration, and that at a very low frequency. Experiments varying the level and composition of micro- and macronutrients, level of thidiazuron and light intensity are continuing in the expectation that conditions can be identified to which at least one of the local varieties will respond. Since regeneration potential has a strongly hereditary component, another variety (Algonquin) which shares a parent with the highly regenerable variety Canby will be tested. That variety is now being raised in the greenhouse.

The coat protein gene from raspberry bushy dwarf virus has been cloned and sequenced. The gene has been inserted into a cassette containing a suitable promoter and polyadenylation signal. It is currently being transferred into an appropriate *Agrobacterium* strain. Transformation experiments will begin as soon as the coat protein gene is transferred to *A. tumefaciens*.

Project No:

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

Year Initiated 1993 Current Year 1994 Terminating Year 1996

Personnel: Robert R. Martin, Agriculture Canada Research Station, 6660 NW Marine Dr., Vancouver, B.C. V6T 1X2, Kirsten Finstad, a post doctorate fellow that will be working on this project.

Justification:

Develop procedures for transforming the major raspberry cultivars grown in the Pacific Northwest. Such protocols are necessary before genetic engineering be applied to improvement of raspberries.

Raspberry bushy dwarf virus (RBDV) is the most common virus disease of raspberries in the Pacific Northwest. Currently, only two raspberry cultivars (Willamette and Chilcotin) grown in this area are resistant to RBDV. Transmission of RBDV is associated with flowering and therefore control is very difficult or impossible by chemical means. With the technology of incorporating plant virus coat proteins stably 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.

This project will impact on all projects that attempt to introduce genes into raspberry. We are working on developing systems for transforming and regenerating raspberries. Once developed

Objectives:

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

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

Procedures:

This project requires a significant amount of tissue culture for plant propagation and regeneration. The major cultivars grown in the Pacific Northwest are put into tissue culture. From these plants leaf and petiole pieces are used to develop a method to regenerate plants from these parts. This is the standard tissues used in plant regeneration for genetic engineering. The virus coat protein is cloned, sequenced and then transferred to Agrobacterium for transformation experiments. This gene will also be combined with a herbicide tolerance gene. Methods to detect DNA, RNA and proteins will be used to ensure the inserted gene is inserted and to determine the level of expression.

Anticipated Benefits and Information Transfer:

Virus resistance will increase the life of raspberry plantings, herbicide tolerance to a relatively safe herbicide will reduce the risk to the operator and the environment. Once developed the regeneration and transformation strategies allows for the easy introduction of additional traits. This may be traits for insect, nematode, or fungal resistance or to add traits that enhance the fruit quality. If Ignite looks like it may be used as a cane burning chemical then obviously it will not be incorporated into raspberry other than for research purposes. We have been promised access to the gene for Ignite resistance. We are still trying to get access to the Roundup resistance.

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

Budget:

Amount allocated in 1993	4500
Request for 1994	5000
Salaries	3500
Travel	500
Supplies	1000

Travel is to attend growers meetings, and to attend a conference on small fruit viruses to discuss this research with colleagues Europe. The group at Scottish Crops Research Institute has been working on raspberry tissue culture and transformation for several years. We hope to learn from their experiences.

Other support:

B.C. Raspberry Growers Assn.	16,000
Oregon Caneberry Commission	3,500
Agriculture Canada National Biotechnology Stratagey Fund	20,000

Commission Funding has made it possible to have a full-time person working on this project. Half of the funds were from the Ag. Can. NBSF, this fund is scheduled to continue again this year. Having growers funds makes it easier to get funds from various granting agencies. In our system, industry input enhances the chance of government funding. In many cases the industry funds are used to get a project started then once we have initial results we are in a better position to obtain other funds.

PROCEDURES:

Mite Feeding: Potted plants in the growth chamber and greenhouse will be used to allow for repetitive experiments and for uniformity of plant material and environment. Mite feeding experiments will continue to consider the impact of physiological reductions at the local and whole plant levels. Radioactive labeling with $^{14}CO_2$ will be integrated into these studies in order to better understand the movement of fixed carbon out of leaves which have been attacked by mites.

Miticides: Miticides will be sprayed on plants in the field under a range of environmental conditions ranging from cool, cloudy weather to hot, dry weather. The degree and duration of depressed physiological processes will be correlated with environmental conditions and stage of plant development.

Mite Resistance \ Tolerance: Physiological and anatomical studies of native and cultivated genotypes which appear to be resistant to, or tolerant of mite feeding will be undertaken in order to understand the basis of these possible defenses. Photosynthesis and fourth derivative spectroscopic analysis of the photosynthetic apparatus will be used as indicators of physiological tolerance to mite feeding. Anatomical analyses will utilize the Bioquant IV Image Analysis System to quantify structural characteristics such as vascular capacity and cell layer arrangements.

Winterardiness: With our recent observation that floricanes appear to contribute carbohydrates to the raspberry plant for many weeks after harvest, the role of floricanes in winterhardiness should be re-evaluated, particularly in light of the timing of their removal and the potential for late season mite damage. Floricanes will be removed from field plots at regular intervals during and after harvest. Winter hardiness, carbohydrate status and plant performance and yield the following season will be monitored. This should provide valuable information with regard to the timing of spent floricane removal and the potential for late season mite damage on winterhardiness and yield.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

Benefits: A better understanding of how mite feeding reduces physiological processes will ultimately determine impacts on yield and sustainable culture. Determining economic thresholds for chemical control based on plant response to the pest is an important aspect of control. Similarly, the potential affect of chemicals on plant productivity with regard to timing and environmental

interactions are part of the cost\benefit approach to integrated pest management. Understanding the basis for tolerance to mite feeding will allow for the design of strategies for genetic improvement of cultivated varieties.

Information\Technology Transfer: This information will be disseminated at regional and national grower's meetings as well as through local, regional, and national publications. This project will be coordinated with the WSU Entomology program at Vancouver and the WSU Small Fruit Breeding program at Puyallup. As promising cultural practices and germplasm are determined, appropriate protocols for technology transfer to industry will be pursued.

BUDGET:

		1993-4 Funding	1994-5 Request
01	Temporary employees	$3,380	$3,500
03	Supplies and services	250	340
05	Computer services	180	---
07	Benefits (16% of 01)	(8%) 270	560
	TOTAL	$3,900	$4,400

OTHER SUPPORT OF PROJECT:

No other sources of funding are currently available or pending for this project. This aspect of our research is one which is not easily marketed to federal and private granting agencies due to its focus on the cultivated raspberry which is considered to be a "minor" or "alternative" crop. We are attempting to include aspects of this research in grant proposals addressing basic physiological and developmental plant biology. While these types of grants may provide us with professional personnel, equipment and supplies for some of the laboratory research, the red raspberry industry is the sole end user of the applied physiology and field studies we are doing. These projects thus require industry support.

PROJECT NO.: NEW

YEAR INITIATED: 1991 **CURRENT YEAR: 1993** **TERMINATING YEAR: 1996**

TITLE: ACHIEVING GREATER YIELD EFFICIENCY FOR WASHINGTON RED RASPBERRY PRODUCTION

PERSONNEL: **J. Scott Cameron**, Associate Horticulturist
Chuhe Chen, **Stephen F. Klauer,** Postdoctoral Research Assoc
Paul W. Foote, **Ann Marie Smith**, **Bruce Kelley** and **Todd Kostman**, Graduate students
WSU Research and Extension Unit, Vancouver

JUSTIFICATION: Horticultural scientists doing research with red raspberries in the Pacific Northwest routinely estimate crop yield potential to be 3-5X greater than the average yields reported by industry. Previous work has shown that our mechanically-harvested canopy may actually account for the loss of 50% of our potential yield through harvester losses and poor light interception/fruit set. The remaining yield potential is still likely to be 2-3 times greater than that which is actually harvested. Yield is a function of cane number, fruit number and fruit size. In its simplest form, yield efficiency relates to obtaining the greatest yield per unit of land area. Theoretically, higher yielding varieties would increase yield efficiency, but we are currently harvesting only a fraction of the yield potential of the cultivars we already have. Plant breeding is an important part of maintaining the productivity of the industry, but plant breeders have little information on the areas of crop improvement which would make the largest gains.

Price fluctuations, limitations on available land, water issues and increasing production costs suggest that a major priority within the industry should be to increase yield efficiency. Increasing yield efficiency can often be a fairly simple and inexpensive process. For example, cane densities in most of our fields are probably too low due to factors which include tradition and over-management. Increasing cane density will increase yield per unit area with possible reductions in fruit size. This will then impact other questions related to internode length, lateral number, canopy architecture and pruning/training practices.

In order to increase yield efficiency, one must first understand the biology of the plant, the influence of the cultural environment, and be able to determine cost effective approaches to improving productivity. Ours is the only program in the Pacific Northwest working on these aspects of cultural physiology. The purpose of

this project is to model the cultural biology of this plant while developing new, cost effective strategies to increase the efficiency of red raspberry culture.

OBJECTIVES: **(All to be addressed in 1994)**

1. Characterize the yield potential of the red raspberry plant in relation to cultural practices.
2. Model interplant and intraplant competition and its influence on cultural management strategies such as optimal cane density and training systems.
3. Initiate studies with cost effective approaches to recovering yield potential.

PROCEDURES:

Cane density: In 1994, cane density will be increased in some plots so as to create significantly increased resource pressure at the inter- and intracane levels. Fruit size and number relationships will be expressed mathematically in concert with other affected yield components. Particular attention will be paid to parameters related to lateral number (internode length), length and fruiting density as they determine potential increases in yield with loss of fruit size.

Tying vs. Topping: An intensive study will be initiated in order to determine the impact of training system on the biology of the raspberry plant. Yield components, plant architecture and physiological parameters will be measured in order to characterize plant and fruit development under these two styles of management. The general purpose of this study would be to analyze potential sources of increased yield, physiological adaptation and compensation between systems. The ultimate goal is to increase the efficiency of our machine harvested canopy.

Radioactive Labeling Studies: A second series of studies will use $^{14}CO_2$ as a radioactive tracer to determine where the products of photosynthesis go during different stages of seasonal growth. In particular, the role of root growth in competing with fruit for products of photosynthesis will be further characterized. We shown that previous reports of floricanes contributing nothing after harvest are probably inaccurate. Now that we have demonstrated that floricanes actually contribute carbohydrates for a significant period after harvest, we will now study this aspect of floricane biology in order to determine the implications of the timing of floricane removal on winter hardiness.

Cytokinins and Leaf Senescence: A second experiment to study the relationship between leaf senescence and cytokinins will be undertaken. This work will attempt to keep floricane leaves from senescing during the last few weeks of the

well as to reserve carbohydrate storage for winter. In 1992, attempts to use a natural form of cytokinin in order to delay leaf senescence were inconclusive. Weekly applications during fruit development did not appear to have a significant influence on plant metabolism or yield. Cytokinins delay leaf senescence, but perhaps with a cool, wet growing season, chlorophyll degradation patterns we've observed in the past were not driven by environmental stress this year. In addition to commercial preparations of naturally occurring cytokinins, synthetic cytokinins will also be tested. Fruit development, photosynthesis and chlorophyll integrity will be monitored in treated and untreated leaves.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

Benefits: Red raspberry growth and productivity are poorly understood, greatly reducing cultural efficiency, productivity and profitability. While new information on plant biology is promising, growers may still only harvest 20-50% of the plant's yield potential. The future of this industry depends upon our ability to increase yield efficiency. Our program has generated considerable new information about red raspberry biology during the past seven years, and is now using this information to test new, cost-effective approaches to increasing yield efficiency.

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

BUDGET:

		1993-4	1994-5
01	Temporary employees	$6,200	$6,200
03	Supplies and services	500	800
04	Travel	300	-----
07	Benefits (16% of 01)	(8%) 496	992
	TOTAL	$7,496	$7,992

OTHER SUPPORT OF PROJECT:

No other sources of funding are currently available or pending for this project. This aspect of our research is one which is not easily marketed to federal and private granting agencies due to its focus on the cultivated raspberry which is considered to be a "minor" or "alternative" crop. We are attempting to include aspects of this research in grant proposals addressing basic physiological and developmental plant biology. While these types of grants may provide us with professional personnel, equipment and supplies for some of the laboratory research, the red raspberry industry is the sole end user of the applied physiology and field studies we are doing. These projects thus require industry support.

and possibly even eliminate the need for fungicidal control. Reducing the amount of fungicide applied to the soil will lower the risk of groundwater contamination. Resistant varieties will be able to be grown on sites even though they are infested.

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

Budget:

Salaries	
Timeslip	$ 250
Operations	400
Travel	150
Projected needs	
Meetings	
Other	
Equipment	500*
Employee Benefits	40
Total	$1,350

* If current problems with deer are not solved it will be necessary to install an electric fence around the research planting. The amount listed is for that portion of the fence to enclose this particular planting.

Other support of project:

Project No.: New

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

Year initiated: 1994 **Current year:** New **Terminating year:** 1996(?)

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

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

No other project in the PNW is addressing this problem. In another proposal Dr. Scott Cameron wants to look at the impact of ridging on the physiology of the red raspberry plant.

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

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

allow their establishment). Once established soil will be thrown up around the plants and Ridomil applications will be discontinue on one half of the plants.

Anticipated Benefits and Information Transfer The results will tell if the raised bed system is of has any value for root rot control under Pacific Northwest conditions. If this cultural practice is shown to be beneficial, it could be included in an integrated approach to control this root disease.

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

Budget:

Amount allocated by Commission for FY 1993-94: none

Request for FY 1994-95

Salaries	
Timeslip	$2,500
Operations	300
Travel	200
Projected Needs	
Meetings	60
Other	
Equipment	
Employee Benefits	400
Total	$3,460

Other support of project:

Project No.: New

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

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

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

Justification: For a number of years, decades even, yellow rust caused by the fungus *Phragmidium rubi-idaei* has not been an economic factor in the culture of red raspberries in the Pacific Northwest. Current plant disease handbooks list the disease as minor. Historically however, yellow rust has played a significant role within the industry. Cuthbert, once the predominant variety, was replaced (along with Marlboro) in part because of its susceptibility to the disease. In this region these varieties were replaced with the resistant Washington and Tahoma varieties. By the mid-1940's however, rust was found on Washington and research conducted at the time showed that a new race of the fungus had evolved. The new race was able to overcome the resistance in Washington.

Today about 60-70% of the red raspberry acreage in the Pacific Northwest is planted to the Meeker variety. Although Meeker is susceptible to yellow rust it avoids major damage because it possesses a character known as slow-rusting. With slow rusting, the disease builds up slowly compared to susceptible cultivars without that trait. During 1993, yellow rust reached epidemic proportions and yield suffered in a number of Meeker fields in both Washington and Oregon. One explanation for the rapid build up was weather conditions during spring and early-summer that were ideal for the fungus. Departure from cultural practices which helped to keep the pathogen in check may have also contributed to the situation. Another explanation is that the pathogen has again changed with the evolution of a race that is capable of overcoming the slow-rusting feature of Meeker.

No other project in the Pacific Northwest deals with this disease.

Objectives: 1) Determine if there is/are a race/races of *Phragmidium rubi-idaei* that can attack varieties such as Meeker. 2) Assess the reaction of different varieties and advanced selections in the breeding program to races of the pathogen present in the Pacific Northwest.

Procedures: Isolates of *P. rubi-idaei* will be collected from numerous locations throughout Washington and Oregon. These isolates will be inoculated onto leaf pieces or leaf disks of a wide range of varieties and reactions recorded to determine if different races exist. Once races have been identified representative isolates of each race will be used to inoculate leaf pieces of many varieties and advanced selections to determine there reaction to the yellow rust disease.

Anticipated Benefits and Information Transfer: If a new races of the pathogen is identified which can overcome the slow-rusting character then a integrated control program will have to developed.

Conversely, if a new race(s) is not found the outbreak of the disease in 1993 was most likely due to favorable weather conditions. Growers will need to implement current control measures to deal with the tremendous inoculum levels now in fields where disease severity was high.

Results will be passed on to users in a number of ways including: expanded information in the PNW Plant Disease Handbook, Berry Basket Newsletter and presentations at the annual meeting of the Western Washington Horticultural Association.

Budget:

Request for FY 1994-95

Salaries	
Time-slip labor	$2,100
Operations	500
Travel	400
Projected Needs	
Meetings	60
Other	
Equipment	
Employee Benefits	336
Total	$3,396

Current & Pending Support

Title of Project	Total $ Amount Requested for 1994-95.	Granting source to which proposal will be submitted.
Physiologic races of the yellow rust fungus in the Pacific Northwest	$1,000.00	Oregon Raspberry and Caneberry Commission
Using Ridomil (metalaxyl) to identify advanced red raspberry selections with resistance to Phytophthora root rot	$ 0.00	Match support will be sought from the Oregon Raspberry and Blackberry Commission for FY 1995-96.

Project No: New *

Title: Identifying market niches for Pacific Northwest berry crops in consumer, food service, and industrial makrets.

Year Initiated: 1994

Personnel: Desmond O 'Rourke, WSU International Marketing Program for Agricultural Commodities and Trade (IMPACT); Charles A. Brun, WSU Cooperative Extension; Brian Brown, Oregon Fruit Products

Justification:

The cool maritime climate of areas west of the Cascades mountains in western Oregon and Washington is highly favorable to the production of commercial small fruits including strawberries, caneberries (red raspberries, black raspberries, Loganberries, blackberries, Boysenberries), and highbush blueberries. Over the 1990-1992 period the farm gate value of all berries produced in Oregon and Washington (excluding cranberries and grapes) has steadily increased to over $100 million dollars as acreage and grower returns have increased. The Pacific Northwest is recognized as the largest supplier of caneberries in North America.

As opposed to other fruit crops that are sold fresh in the food service sector, a large percentage of Northwest berry crops are processed (bulk frozen, individual quick frozen, puree, concentrates, canned, or aseptic packs) for latter sale to industrial users. Manufacturers use them in bakery foods; breakfast cereals; candy, gum and snacks; condiments, dairy products; juice drinks and wines; and in desserts. Fresh sales constitute 10-17% of the strawberry market, 2-3% of the caneberry market, and 24-29% of the blueberry market.

Both Oregon and Washington have active commodity commissions that collect grower assessment revenues to fund research and promotion. Despite the efforts of the commodity comissions, the promotion and market research expenditure levels have not been enough (less than 1% of farm value) to prevent an erosion of real prices received by growers. Funds have not been spent on joint promotion efforts. Previous marketing studies have dealt mainly with the food service and industrial users. There has not been a uniform market research study, covering all of the various fruit types, to determine consumer perceptions towards the different small fruits grown in the Northwest.

* *This project is part of a large, joint funded marketing study involving all Northwest small fruit crops (with the exception of cranberries). The fourth page of this proposal outlines the other sources of funding.*

Objectives:

The objective of this study is to gauge and document consumer awareness and preferences for Northwest small fruits, in both processed and fresh formats, via a telephone survey. Currently there is little published information available to the Northwest small fruits industry with regards to which consumer categories (e.g. specific age groups, regional markets, ethnic and income groups) are the primary consumers of Northwest small fruits and fruit based processed products.

In addition to the survey, this project will utilize, gather, and disseminate present information concerning successful small fruit marketing techniques that are available from various sources, including Northwest commodity commissions, universities, state departments of agriculture and other organizations.

The results of the survey will be readily available from the NCSFR, a publicly funded entity. Small fruit commissions, and individual grower/processors will be able to use this information to plan future commission activities, including promotional efforts. Food service and industrial buyers will be able to alter manufacturing techniques to meet the most current consumer demands. University research and extension faculty associated with the NCSFR will be able to use the survey data to plan for future market research.

A secondary objective of this study will be to bring the individual commodity commissions together in order to coordinate combined promotional efforts. As with other agricultural commodities, coordinated promotion efforts that encompass more than one growing region, are generally more efficient and effective.

Proposed Research:

This comprehensive two-phase project will involve a Market Research study (Phase I) and an Educational Plan (Phase II). Funding for Phase I will be requested from the USDA Agricultural Marketing Service Federal-State Market Improvement Service (FSMIP), the NCSFR, and the individual small fruit commodity commissions in the Pacific Northwest. Phase II funding will be requested from the NCSFR and Northwest small fruit commodity commissions.

Phase I, Market Research: During Phase I of the project a consumer survey will be developed and utilized to assess perceptions towards Northwest fruit. Data collected include:

- Consumer shopping habits
- Ability to recognize various product types
- Preferences for fresh and processed berries
- Suggestions for new product types
- Incentives that would stimulate further consumer interest in small fruits

During the survey confidential records will be kept concerning the respondents age group, marital status, and educational and income level. This demographic information will be used for classification purposes only.

Secondly, a thorough review of the promotional activities of the various Northwest small fruit commissions, both present and past, will be compiled in order to determine which efforts have been most successful.

Anticipated Benefits and Information Transfer:

Phase II, Educational Plan: Upon completion of the survey in Phase I, the educational plan (Phase II) will begin. Results of the survey from Phase I will be compiled into a format that can be presented to all segments of the small fruit industry. A bound report will be produced that will serve as the basis for determining future promotional activities. As this study will be conducted primarily by a University based organization, the findings will be public domain and thus easily accessible by all parties. The report will serve as blueprint for Northwest small fruit commodity commission promotional activities in the future.

Secondly, a group mediator will be hired to help bring the different commissions together to explore joint promotional efforts. Mediation workshops will be held during the winter when growers normally attend their commodity commission planning sessions.

Budget:

Operations	$ 3,000
Total	$ 3,000

Other support of project:

This project is part of a large, joint funded marketing study involving all Northwest small fruit crops (with the exception of cranberries). The following table outlines the other sources of funding.

Pending Support

Title of Project	Total $ Amount requested for 1994-1995	Granting source to which proposal has or will be submitted.
Identifying market niches for Pacific Northwest berry crops in consumer, food service, and industrial markets.	$ 3,000	Washington Red Raspberry Commission
	$ 3,000	Oregon Raspberry/Blackberry Commission
	$ 1,500	Oregon Blueberry Commission
	$ 1,500	Washington Blueberry Commission
	$ 2,000	Northwest Food Processors Association
	$ 18,000	Northwest Center for Small Fruits Research
	$ 40,000	USDA Agricultural Marketing Service Federal-State Marketing Improvement Program (FSMIP)
	Total: $ 79,000	

PROJECT NO: New

TITLE: Raspberry Farm Improvement Clubs

YEAR INITIATED 1993 CURRENT YEAR 1993 TERMINATING YEAR 1994

PERSONNEL: David Granatstein, Coordinator, Center for Sustaining Agriculture and Natural Resources (CSANR), Washington State University and Gwendolyn Bane, Agricultural Program Associate, Northwest Coalition for Alternatives to Pesticides (NCAP).

JUSTIFICATION: Washington red raspberry growers need more reliable information on regional, sustainable farming practices. A third of the respondents in a survey done by NCAP, *Crop Management Practices in 1992: A Survey of Washington Red Raspberry Growers,* agreed that more information on alternative practices would enable them to farm economically and reduce pesticide use. However, only 13 percent of the respondents felt existing public agencies had effectively supplied them with such information. Over half of the growers wanted the Washington Red Raspberry Commission to research sustainable alternatives that reduce dependence on pesticides.

Nineteen percent of the growers surveyed already successfully produce certified organic raspberries with biologically based practices and little-to-no pesticides. These and other innovative raspberry growers are an important base of readily applicable information on sustainable raspberry production. In *Crop Management Practices,* both extension publications and other farmers were equally rated as the most important source of useful, technical information on raspberry production. As Fred Kirschenmann, manager of Kirschenmann Family Farms of South Dakota explains, "Farmers have always adopted to innovation through a social matrix that evolves in rural coffee shops, field demonstrations and other farmer-to-farmer networks."

A successful and popular way of building farmer-to-farmer networks and directly involving farmers in setting research priorities is through farm improvement clubs. Farm improvement clubs are small groups of growers (3 or more) that cooperatively design and conduct their own on-farm research, usually in conjunction with technical support. Seventy-nine percent of the respondents of *Crop Management Practices* felt that farmers need to be more involved in directly setting research priorities. Through small farm improvement clubs, growers set their own research priorities and problem solve on their own farms. Small grants serve as a catalyst to move local groups of farmers from thinking about an experiment to doing it.

The farm improvement clubs (a) build supportive networks of producers, research personnel and others in the agricultural industry, (b) increase farmers problem solving capacities and (c) efficiently transmit sustainable agricultural information.

Due to their ability to strengthen both sustainability and rural communities, farm improvement clubs are fast becoming a popular form of research in the Northwest. Montana's Alternative Energy Resources Organization, a grassroots educational organization, and the Montana Department of Natural Resources and Conservation currently serve 175 farmers through a farm improvement club program. The Ag Options Network, a coalition of agricultural and conservation organizations helping farmers and ranchers in Montana, Idaho, and eastern Washington adopt sustainable farming systems, sees the development of farm improvement clubs as one of its major thrusts. The Western Oregon On-Farm Research Program, which began in 1991, is a competitive small grants program for sustainable agriculture similar to the farm improvement club model. This program, in addition to other on-farm, farmer initiated research, is coordinated by Oregon State University. Growers in the Skagit Valley and eastern Washington have also participated in farmer initiated on-farm research coordinated by Washington State University Cooperative Extension.

OBJECTIVES:

1. To develop and test the farm improvement club model as a method of increasing the problem-solving capacity of red raspberry growers in Washington.
2. To use on-farm experimentation to generate and disseminate new information on farming practices that improve the long-term sustainability of red raspberry production.

PROCEDURES: NCAP and CSANR will work cooperatively with local specialists and scientists, and the Washington Red Raspberry Commission to develop a one-year, pilot project for farm improvement clubs. There are four primary components of this pilot project: A) development of farm improvement clubs for Washington red raspberry growers who wish to do on-farm, sustainable research and demonstration projects; B) club project implementation and technical assistance; C) information dissemination and networking among farm improvement clubs, researchers, farm and environmental organizations, and consumers; and D) evaluation.

A. Farm Improvement Club Development. NCAP and CSANR will publicize the raspberry farm improvement club idea and encourage farmer participation. In January 1994, NCAP will distribute a request for farm improvement club proposals, seeking groups of three or more red raspberry growers who want to cooperate on on-farm experiments or demonstrations that meet their collective needs. A club will be eligible to receive up to $800 of financial assistance to carry out their project. CSANR will arrange for assistance to growers for proposal development. A five person evaluation committee organized by NCAP and CSANR will meet in February to review and select proposals. The committee will have representatives from raspberry growers, research/extension, the raspberry commission, raspberry industry, and

environmental/consumer groups. NCAP will notify applicants of their proposal status in March.

B. Technical and Assistance. NCAP and CSANR will assist the clubs with successful proposals in defining their needs for project implementation and identifying who will preform the various tasks. NCAP will manage the distibution of grant funds to the clubs. NCAP and CSANR will jointly monitor the progress during the season, including a site visit.

C. Dissemination. Each club will be responsible for collecting data and keeping records as specified in the proposals. Clubs will host at least one farm tour or present information at established functions to further disseminate results. Each club will be required to write a brief, year-end summary of its project to be submitted to NCAP and CSANR. All farm improvement club members will meet at a statewide forum sponsored by NCAP and CSANR to exchange technical, practical and organizational information. This forum will also serve as an arena for farm improvement club members to evaluate and modify the overall program and create strategies for future directions of the program. The forum will be held in conjunction with an established event such as the Western Washington Horticultural meetings.

CSANR will assist compiling year-end summaries and disseminating the reports to all raspberry farm club cooperators, the Red Raspberry Commission, researchers and others. NCAP will publish highlights of the results of the farm improvement clubs in its quarterly, *Journal of Pesticide Reform.* NCAP and will submit highlights of the project to regional sustainable agricultural, consumer and farmer publications.

D. Evaluation At the year's end an evaluation of each club project and the overall project will be conducted by the farm improvement club members, technical assistance providers, cooperators, the selection and review committee, NCAP, CSANR, and the Washington Red Raspberry Commission. This evaluation may be done, in part ,at the statewide forum. Also an outside evaluator will assess the overall success of the project. If there is consensus about the success of the project, strategies will be developed to continue the clubs into the future.

ANTICIPATED BENEFITS: This project will enable Washington red raspberry growers to increase the development and transfer of sustainable production practices. It is intended to be a pilot project, exploring the potential for a continuing raspberry farm improvement club program. By relying on technical support from local researchers, extension specialists and other farmers, this project both strengthens collaboration and builds a strong sense of community.

The farm improvement clubs become learning networks beyond each individual club. Through club-hosted events such as tours and seminars, the public can learn from local raspberry growers. Farm improvement clubs create new areas of sustainable systems research for researchers and industry. The club networks can also serve as ready, reliable means of testing practices within a successful farming

system. These networks have the capacity to be an excellent vehicle for transferring newly developed technologies to producers.

BUDGET: FY 1994-95

	NCAP	WSU CSANR
Salary	$1881.00	-
Timeslip	-	-
Operations		
Phone, mailing,etc.	410.00	400.00
Meeting rm rental	-	200.00
evaluation	400.00	-
Grants to farm clubs	2300.00	-
Travel		
One site visit	200.00	-
Farmers forum	200.00	-
Review Co meeting	160.00	-
Projected needs	-	1200.00
Equipment	-	-
Employee Benefits	395.00	-
Total	$5946.00	$1800.00

Total Request $7746.00

Notes: Salary is figured at 209 hours of program associate's time at $9.00 an hour. Travel will be for NCAP and CSANR investigators to organize clubs, visit farms, and attend project meetings. Also, travel expenses for the evaluation committee will be covered.

OTHER SUPPORT OF PROJECT: NCAP will be contributing $200 and will be soliciting small contributions for the grants to the farm clubs from the following organizations and foundations:The MRCW Foundation, The Mountaineers Foundation, The Acorn Foundation, Pacific Northwest Pollution Prevention Research Center, The Tides Foundation, Washington Sierra Club, National Audobon Society, Washington State Office, Washington Environmental Council and Washington Foundation for the Environment.