Northwest Cherry Research Review
Washington Tree Fruit Research Commission and Oregon Sweet Cherry Commission
8-9 November 2001
Wenatchee Valley College

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12:00-1:30	**Lunch**			
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CONTINUING PROJECT **YEAR 2**

WTFRC Project #: OSCC-2

Project title: Sweet cherry cultivar collection

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Objectives:
To evaluate and select outstanding sweet cherry cultivars for the Mid-Columbia area with respect to harvest date, cropping, fruit size and quality, incidence of disease, and susceptibility to rain cracking. There is particular interest in finding high-yielding material that is harvested outside of the peak season of early July, with large, firm fruit. Desirable canopy growth characteristics include open branch angles and a non-clustering fruiting habit.

Significant findings for 2001:

- 13S-21-7: this selection has good fruit quality and is harvested between 'Bing' and 'Lapins', although it has shown some susceptibility to rain cracking. Trees show good branch angles.

- 13S-21-1: fruit is comparable to 'Bing' and has good flavor and firmness; the main attribute of this selection is its extreme lateness (mid- to late August). During 2001, it showed severe susceptibility to powdery mildew while still unripe. Its cultivation would likely require intense powdery mildew management during years of high pressure.

- 8S-3-13: early, with large fruit of good flavor; and good crop load. Trees are relatively vigorous, with good branch angles.

Methods:
Observations are being made on vigor, cropping, maturity, and fruit quality in The Dalles and at the MCAREC in Hood River. Most trees in The Dalles were planted in 1996 (Table 2). Trees are trained to a steep leader and they are grafted onto Mazzard rootstock unless otherwise noted. Trees in The Dalles were treated with 25 ppm GA_3 during 2001. Trees in Hood River were planted in 1994 and trained as a central leader. Selections with poor performance will be eliminated from the collections and new, promising ones will be added as they become available to the program.

Fruit firmness was determined using a FirmTech2 instrument (BioWorks, Inc., Stillwater, OK), which measures the amount of pressure in grams required to compress individual fruit by 1 mm (g/mm). Fruit with firmness values of 241-290 g/mm are considered average; values higher than 290 g/mm correspond to very firm fruit; values of 191-240 g/mm indicate caution for softness and values of 190 g/mm or lower indicate softness (T. Schmidt, personal communication). Firmness values reported here are the average of a sample consisting of 25 fruit (Table 3).

The Firmtech2 simultaneously measures firmness and the diameter of individual fruit. The row sizes reported here are based on the ranges reported for each row size by the Washington State Fruit Commission.

Results for 2001:

Bloom time

In Hood River, the earliest full bloom was recorded on 'Lapins', 8S-3-13, and 13S-24-21 (April 18), and the latest was recorded on 'Regina', 'Sylvia' and 'Viva' (April 30). In The Dalles, full bloom occurred first on 'Lapins' (March 21) and last on 'Sylvia' (April 25) and 'Regina' (April 26).

Tree vigor (trunk cross sectional area)

The smallest trunk cross sectional area (TCSA) for trees planted in 1996 (the majority of the collection) were measured in 'Bing'/G6 and 'Bing'/G5 (104.0 and 105.1 cm^2, respectively; Table 2). The largest trunks were recorded for 'Newstar', 8S-3-13 and 'Lapins' (in Marchand system), with values of 249, 256, and 239 cm^2 TCSA.

Fruit size

'Bing' trees produced fruit averaging 9.4 g (in Marchand system) to 11.4 g (on Mazzard steep leader); fruit diameters were between 28 and 30 mm for 'Bing' (9.5 to 9 row). The largest fruit weights occurred in 13N-7-19 (17.3 g), 8S-3-13 (16 g), 'Sandra Rose', 'Newstar', 'Sonata', and 'Regina' (all with weights of at least 15 g). Fruit from all these extra-large cultivars had average diameters exceeding 33 mm (8-row). More than 95% of the fruit samples from these cultivars consisted of fruit of size 9-row and larger.

Maturity

'Bing' was considered to be ripe on July 3 in The Dalles (Table 3). Cultivars maturing before 'Bing' included 'Cristalina', 'Newstar', 8S-3-13 and 13S-8-33. 'Lapins' was considered ripe on July 26. Cultivars maturing after 'Lapins' included 13S-21-1, 'Staccato' (both ripe on August 9), and 'Symphony'.

Fruit firmness

Firmness varied greatly due possibly to the different maturity stages on the different evaluation dates (Table 3). Across cultivars, firmness did not appear to be directly correlated to maturity stage (for example, under-ripe 'Symphony' and 'Sylvia' fruit had firmness values of only about 240 g/mm, whereas over-ripe fruit of 'Regina' and 13S-21-7 had firmness values above 300 g/mm). This year's preliminary firmness measurements indicate a tendency for soft fruit in 'Sylvia' (239.8 g/mm) and 'Symphony' (247.3 g/mm), since these values were obtained from fruit that was considered unripe, and these values were expected to decrease as fruit maturity advanced. 'Sandra Rose' appeared to be less firm than 'Bing' (Marchand).

Rain cracking

Observations on susceptibility to rain cracking were made on June 28, after two rain events occurring on June 25 and 26. Observations were limited mainly to named cultivars. 'Lapins' and 'Sylvia' had slight damage; 'Sandra Rose', 'Newstar', 'Sonata' and 'Cristalina' had slightly less damage than 'Bing'. 'Bing' had close to 30% on lower branches, while 4W-11-8 (still with very unripe fruit) had the most severe damage.

Powdery mildew

Moderate infection levels by powdery mildew were observed in 13S-49-24. Incidence of mildew on 'Sweetheart' varied with rootstock: compact trees grafted onto Gisela 6 rootstock had substantially greater mildew damage than trees grafted onto Mazzard, which had more open canopies and little

clustering compared to trees on Gisela 6. Severe mildew damage was observed on 13S-21-1, to a degree that rendered the crop non-harvestable.

Discontinued and new material
Five selections were removed in 2001 from the collection in The Dalles due to poor performance: 13S-8-33, 13N-7-19, 13S-17-40, 13S-49-24, and 13S-24-21. New selections added this year to the collection in The Dalles include NY007, NY304, NY252, NY2131, and NY418033, from Dr. Bob Andersen's program in New York, and Liberty Bell and Early Robin from the Prosser, WA program.

Budget:
Sweet cherry cultivar collection
Roberto Núñez-Elisea
Project duration: continuous renewal
Current year: 2002
Original budget request:

Year	Year 1 (2001)	**Year 2 (2002)**	Year 3 (2003)
Total	$3,500	**$4,500**	$6,500

Current year breakdown:

Item	Year 1 (2001)	**Year 2 (2002)**	Year 3 (2003)
Salaries (Res. Assist.)		**$3,160**	
OPE (42.4 %)		**1,340**	
Service and supplies			
Travel			
Total	$3,500	**$4,500**	$6,500

Table 1. Time of sweet cherry bloom for various cultivars and selections in Hood River and The Dalles, 2001.

Cultivar/Selection*	Research Station, Hood River		Cemetery Block, The Dalles	
	First white (popcorn)	Full bloom	First white (popcorn)	Full bloom
'Santina'	-	4/25	-	-
'Viva'	4/19	4/30	-	-
'Lapins'	4/8	4/18	3/31	4/15
'Sweetheart'	4/12	4/24	4/3	4/18
13N-7-19	-	-	4/4	4/18
'Bing'	-	4/22	4/5	4/19
'Bing'/G5	-	-	4/2	4/19
13S-49-24	4/11	4/21	4/5	4/19
13S-18-15	-	-	4/6	4/19
8S-3-13	4/11	4/18	4/6	4/19
'Van'	-	4/24	4/4	4/20
'Bing'/G6	-	-	4/3	4/20
'Sonata'	-	-	4/6	4/20
'Symphony'	-	-	4/4	4/20
13S-17-40	4/12	4/25	4/8	4/20
13S-8-33	-	-	4/7	4/20
4W-11-8	4/15	4/26	4/7	4/20
'Staccato' (13S-20-9)	-	-	4/4	4/21
'Cristalina'	4/14	4/25	4/8	4/22
13S-21-7	-	-	4/6	4/22
'Newstar'	4/11	4/24	4/5	4/23
'Sonnet'	4/14	4/24	4/10	4/23
13S-24-21	4/10	4/18	4/7	4/23
13S-21-1	-	4/25	4/8	4/23
'Sandra Rose'	-	4/26	4/10	4/24
13S-42-49	4/11	4/26	4/11	4/24
'Sylvia'	4/20	4/30	4/13	4/25
'Regina'	4/20	4/30	4/15	4/26

* All selections and cultivars on Mazzard rootstock unless designated otherwise

Table 2. Sweet cherry cultivars and selections under evaluation in The Dalles, 2001.

Selection/ Cultivar	Year planted	TCSA (cm^2)	Crop load Estimation	Distinguishing qualities
'Cristalina'	1996	229.55	Good	early, firm, good flavor
'Newstar'	1996	248.90	Good	large, early
8S-3-13	1996	255.56	small-medium	large, early, firmer than Newstar
(13S-8-33)*	1996	135.74	small-medium	-
'Sylvia'	1996	178.44	medium-good with some clustering	large, later than Bing
(13N-7-19)*	1996	205.35	-	-
Bing/Marchand	1996	244.89	medium-good	standard for comparison
'Bing'/G5	1996	105.13	Good	standard for comparison
'Bing'/G6	1996	103.96	Good	standard for comparison
'Sonata'	1996	201.56	small-medium	firm, large, later than Bing
'Sandra Rose'	1996	227.56	Small	large, later than Bing
'Sonnet'	1997	130.73	very small	late
13S-21-7	1996	181.91	medium with some clustering	firm, good flavor, mid season
(13S-17-40)*	1996	138.10	good with strong clustering	-
13S-18-15	1996	165.22	small	light flesh, later than Bing
13S-49-24*	1996	172.43	-	-
13S-42-49	1996	228.22	small-medium	-
'Symphony'	1996	244.05	small-medium	very late
4W-11-8	1996	135.78	medium-good	blush type, light flesh, late
'Lapins'/ Marchand	1996	238.89	medium-good	standard for comparison
'Regina'	1997	169.31	small	late, rain crack resistant
'Sweetheart'	1996		good to over-set	late, large, firm
'Staccato'	1997	176.68	small	late, good tree angles, good flavor
13S-21-1	1996	172.57	good	good flavor, very late
'Skeena'	1998	50.95	none	good tree angles, late, large
(13S-24-21)*	1996	191.83	Very small	-
'Santina'	1998	57.28	none	early
13S-16-29	1997	106.62	none	no info yet
'Attika'	1996	195.08	-	late, consistently big fruit

( )* selections eliminated in 2001 due to poor performance.

Table 3. Fruit maturity and size of selections and cultivars under evaluation at The Dalles, 2001.

Selection/ Cultivar	Date	Ripeness status	Fruit wt. (g)	Fruit diam. (mm)*	% of fruit number* 9-row and larger	% of fruit number* 8-row and larger	Firmness (g/mm)*
'Cristalina'	28-Jun	under-ripe	11.5	-	-	-	-
'Cristalina'	03-Jul	over-ripe	11.6	30.4	64	4.0	285.5
'Newstar'	28-Jun	under-ripe	14.6	-	-	-	-
'Newstar'	03-Jul	over-ripe	15.4	33.3	100	48.0	216.0
8S-3-13	28-Jun	under-ripe	16.0	-	-	-	-
8S-3-13	03-Jul	over-ripe	16.5	34.7	100	76.0	250.4
13S-3-13	28-Jun	under-ripe	11.6	-	-	-	-
13S-3-13	03-Jul	over-ripe	12.1	29.7	48	4.0	218.7
'Sylvia'	03-Jul	under-ripe	12.3	30.5	76	8.0	239.8
'Sylvia'	06-Jul	over-ripe	13.4	31.5	92	4.0	265.0
13N-7-19	03-Jul	ripe	17.3	35.3	100	88.0	258.7
'Bing'/Marchand	03-Jul	ripe	9.4	27.9	4	0.0	330.3
'Bing'/G-5	03-Jul	ripe	11.3	29.5	52	0.0	251.2
'Bing'/G-6	03-Jul	ripe	10.8	28.7	20	0.0	235.3
'Bing'/ steep leader	03-Jul	ripe	11.4	30.0	60	0.0	272.8
'Sonata'	06-Jul	under-ripe	13.6	32.3	96	32.0	300.8
'Sonata'	13-Jul	over-ripe	15.0	33.6	96	60.0	263.7
'Sandra Rose'	06-Jul	ripe	15.3	33.7	100	57.7	257.6
'Sonnet'	06-Jul	ripe	13.4	30.0	80	0.0	293.2
13S-21-7	06-Jul	under-ripe	12.6	32.3	100	32.0	408.7
13S-21-7	13-Jul	over-ripe	12.5	30.9	76	0.0	310.5
13S-17-40	06-Jul	ripe	12.5	31.1	80	8.0	302.2
13S-18-15	06-Jul	ripe	10.9	31.8	100	28.0	314.5
13S-49-24	13-Jul	under-ripe	13.2	31.8	96	16.0	252.2
13S-49-24	19-Jul	over-ripe	13.8	32.1	96	16.0	241.8
13S-42-49	19-Jul	ripe	13.6	31.7	96	40.0	344.1
'Symphony'	26-Jul	under-ripe	11.1	27.8	44	0.0	247.3
'Symphony'	03-Aug	over-ripe	11.1	30.2	56	0.0	257.8
4W-11-8	26-Jul	ripe?	11.7	29.9	48	8.0	290.3
'Lapins'	26-Jul	ripe	11.5	29.6	40	0.0	240.6
'Sweetheart'	26-Jul	4 days before harvest	13.1	31.8	80	28.0	322.1
'Regina'	26-Jul	under-ripe	14.0	31.5	84	16.0	279.1
Regina	03-Aug	over-ripe	15.2	34.0	95	75.0	304.8
'Sweetheart'/ G-6	26-Jul	4 days before harvest	12.4	30.9	76	4.0	321.1
'Staccato'	09-Aug	ripe	10.7	30.2	60	4.0	335.9
13S-21-1	09-Aug	under-ripe	10.5	29.8	32	0.0	300.9

* from a sample of 25 fruit

CONTINUING PROJECT **YEAR 2**
Project #: OSCC-3

Project title: Pruning, training, rootstocks, and irrigation management in sweet cherry

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Research Assistant: Helen Cahn, OSU-Mid-Columbia Agric. Res. & Ext. Center

Objectives:

- To evaluate the vigor, yield, and fruit characteristics of 'Bing' sweet cherry as influenced by different rootstocks and three training systems. Rootstocks under evaluation were chosen for their potential to be more precocious or more compact than Mazzard.

- To assess the impact of four training systems and the use of synthetic fabric row covers on performance of 'Lapins'/Gisela 11 sweet cherry.

- To evaluate the potential of deficit irrigation as a tool to induce precocity and control vigor of 'Lapins' sweet cherry grafted onto Mazzard rootstock.

Significant findings for 2001:

- Maxma 14, Edabriz (very dwarfing), Pontaleb (previously known as '2845'), Weiroot 72 and Weiroot 158 have shown promising performance and deserve further evaluation. P50, Saint Lucie 64, Weiroot 154 and Gisela 4 have been discontinued from further evaluation due to poor performance or sensitivity to viral diseases.

- Maxma 14 and Edabriz produced high yields, while Mazzard continued to produce very low yields. Weiroot 72 produced high yields, with 73% of fruit being 10-row or larger. Weiroot 154 produced moderate yields but fruit of good size. However, fruit size and firmness among Weiroot, Gisela 4 and Mazzard rootstocks were not significantly different.

- Mazzard and Pontaleb produced large proportions of larger fruit (40% and 55% of fruit in the 9.5-row and larger range), whereas Edabriz and Maxma 14 had 9% and 22% of fruit in this size range.

- In the NC-140 rootstock trial, Giessen 195-20, Gisela 4 and Gisela 7 produced the highest yields (36 to 42 lbs/tree), but with modest fruit size (6.4 to 8.4 g). Gisela 5 and Gisela 6 produced both good yields and large fruit (nearly 30 lbs/tree with fruit weighing an average of 9.5 to 9.9g).

- 'Lapins'/Gisela 11 trees planted in 1996 at the MCAREC in Hood River produced a greater proportion of large fruit (60% of the number of fruit sampled was 9-row and larger) when trained as a central leader with Promalin applied in the spring of 1997, compared to trees trained in the Spanish bush, steep leader system, or Vogel central leader system trained without Promalin application.

Methods:
Hazel Dell rootstock trial in The Dalles. Two adjacent but separate trials were established in The Dalles to evaluate the performance of 'Bing' and Royal Anne grafted onto different rootstocks. Trees on Edabriz (*P. cerasus*) Maxma 14 (Mazzard *x P. mahaleb*), St. Lucie 64 (*P. mahaleb*), Pontaleb (2845: *P. mahaleb*) and Mazzard were planted in 1997 ('French section'; 21 to 45 trees per rootstock), and trees on Weiroot 13, 158, 53, 72 and 154, and Gisela 4 were planted in 1998 ('Weiroot section'; 13 to 20 trees per rootstock). Trees in both plots were trained as steep leader (the traditional system in the area), central leader Vogel, or a Spanish bush. Trees of Royal Anne and several non-promising rootstocks (see Table 1) were discontinued from the study in 2001 to allow for initiation of new research projects.

NC-140 rootstock trial in The Dalles. A planting was established in 1998 at Orchard View Farms to evaluate performance of 'Bing' on different rootstocks. Trees are trained to a central leader. Measurements of tree vigor, flowering and fruiting efficiency, and fruit characteristics were made during 2001.

Training systems and row covers in 'Lapins'/Gisela 11. A planting of 'Lapins' on Gisela 11 rootstock was established in Hood River in 1996 to compare four training systems: steep leader, Spanish bush, and two variations of the central leader system (Vogel central leader and central leader with Promalin (7,500 ppm in latex paint) applied to all terminal growth in spring of 1997. Trees of each training system are grown either with or without woven plastic (DeWitt 'Sunbelt', Sikeston, MO) row covers.

Deficit irrigation in 'Lapins'/Mazzard. A plot of 'Lapins'/Mazzard trees was planted in 1999 at the MCAREC to study the effects of different levels of water deficit on tree vigor and precocity. Deficit irrigation regimes are based on replacement of weekly evaporation (control = 100% evaporation replacement; deficit = 50% or 25% replacement) at 7-day intervals, as determined with a class 'A' evaporation pan. Stem water potential was measured at 7-day intervals with a portable pressure bomb.

In 2001 we began to measure volumetric soil water content using a portable capacitance sensor (Sentek 'Diviner 2000', Kent Town, South Australia). A portion of this plot that is currently trickle-irrigated will be used in 2002 to test new irrigation management treatments, including partial root-zone drying.

Results for 2001:

Hazel Dell rootstock trial in The Dalles

Discontinued rootstocks: P50, Saint Lucie 64, Weiroot 154 and Gisela 4 have been discontinued from further evaluation due to poor performance or sensitivity to viral diseases.

Tree vigor: Based on measurements of trunk cross sectional area (TCSA), Edabriz had significantly less vigor (TCSA = 63.2 cm^2) than Mazzard, Maxma 14, or Pontaleb, which were all equally vigorous (TCSA > 148 cm^2; Table 1). Saint Lucie 64 produced extremely vigorous trees (217.1 cm^2 TCSA). In the Weiroot plot, W72 and W154 were significantly less vigorous than Mazzard (TCSA = 34.1, 59.8, and 94.7 cm^2, respectively).

Yields: Maxma 14 and Edabriz, now in 5th leaf, produced significantly higher yields (4.4 and 4.2 tons/acre, respectively) than all other rootstocks. Mazzard continued to produce the lowest yields, with only 0.25 tons/acre. In the Weiroot plot (4th leaf), W72 produced 2.4 tons/acre, whereas Mazzard produced only 0.1 tons/acre (Table 1).

Fruit size: Pontaleb and Mazzard produced the largest fruit (Table 1), whereas Pontaleb had higher a proportion (85%) of fruit of size 10-row and larger than all other rootstocks except Mazzard (Fig. 1). Almost no fruit larger than size 8.5-row was produced by any rootstock (Mazzard was highest with only 2% in this category). Edabriz produced the smallest fruit (Table 1), with 62% in the 10.5-row and smaller range (Fig. 1). In the Weiroot plot there were no significant differences among rootstocks with respect to fruit weight, diameter or firmness.

Fruit firmness: Mazzard produced significantly firmer fruit than Maxma 14, Edabriz, and Pontaleb (356 vs. about 290 g/mm). However, it is possible that these values reflect different maturity stages, as fruit from Edabriz, Pontaleb, and Maxma 14 appeared to be slightly over-ripe at harvest. It is possible, therefore, that fruit on these rootstocks matured earlier than fruit on Mazzard, an aspect that requires closer observation.

Training systems: results to date do not allow for a conclusion on the effect of training system in tree performance. So far, there appears to be a tendency for Edabriz and Maxma 14 to produce larger fruit when trees are trained to steep leaders.

NC-140 rootstock trial

Yields in 2001 increased greatly compared to 2000. Highest yields were obtained from Giessen 195-20, Gisela 4 and Gisela 7, although fruit size was modest (Table 2). Gisela 5 and Gisela 6 produced both good yields and large fruit. The number of fruit per cm of branch length ranged from 0.37 fruit/cm in Weiroot 154 to 3.8 fruit/cm in Giessen 209-1. Weiroot 154 had the least amount of fruit per unit branch length, among the lowest yield and a low number of fruit per floral bud (1.4). It also had the largest fruit at 9.8 g (Table 2).

Training systems and row covers in Lapins/Gisela 11

Trees were in their 6th leaf in 2001. Trees of central leader Vogel produced significantly higher yields (42.7 kg/tree) than steep leader, central leader Promalin or Spanish bush trees (range 32 to 37 kg/tree); however, yields on a per acre basis were not significantly different among training systems due to the smaller spacing between Spanish bush trees (data not shown).

Trees trained as a central leader with Promalin application produced a greater proportion of 9-row and larger fruit (60% based on the number of fruit) than trees trained as a Spanish bush, steep leader system, or Vogel central leader system (about 38%, 20% and 20% of fruit; Fig. 2). Central leader-Promalin trees grown with row covers produced 77% of fruit in the 9-row size or larger range, whereas trees with row covers in the other training systems produced 20% (Spanish bush and central leader Vogel) to 35% (Spanish bush) of fruit in this category (data not shown).

Deficit irrigation in 'Lapins'/Mazzard

Trees are still too young (3rd leaf) to fully determine the effect of deficit irrigation on precocity. During 2001, trees subjected to both deficit irrigation levels produced more flowers than controls. Based on a scale of three flowering levels (0 to 25, 26 to 50, and >51 flowers/tree), more than 20% of trees subjected to deficit irrigation (both 25% and 50% weekly evaporation replacement) had > 51 flowers/tree, while only 2.8% of control trees fell in this category (data not shown). This response suggests an initial effect of deficit irrigation in promoting precocity of Mazzard rootstock and will be observed more closely in 2002. Trees subjected to deficit irrigation were less vigorous than controls (data not shown).

Table 1. Vigor, yield and fruit characteristics of 'Bing' on different rootstocks. Hazel Dell, The Dalles, 2001.

Rootstock	TCSA (cm^2)	Yield[y] (lbs/tree)	Yield[y] (ton/acre)	Fruit characteristics: Weight (g)	Fruit characteristics: Diam. (mm)	Fruit characteristics: Firmness (g/mm)
French Section (planted 1997)						
Maxma 14	160.7 b[z]	46.0 a	4.4 a	8.6 b	27.2 b	295.2 c
Edabriz	63.2 c	36.8 ab	4.2 a	7.4 c	25.4 c	295.7 c
Pontaleb (2845)	156.3 b	27.6 b	2.7 b	9.6 a	28.3 a	286.3 c
Saint Lucie 64[x]	217.1 a	12.2 c	1.3 bc	8.8 b	27.3 b	322.3 b
P50[x]	152.9 b	10.1 c	1.0 c	8.4 b	26.9 b	337.1 ab
Mazzard	148.5 b	2.8 c	0.25 c	9.1 ab	27.7 ab	355.6 a
Weiroot Section (planted 1998)						
Gisela 4[x]	47.8 b	23.9 a	2.8 a	8.7	26.9	287.4
W72	34.1 c	21.9 ab	2.4 ab	8.9	27.2	274.4
W158	90.6 a	12.9 bc	1.2 bc	9.5	28.1	318.1
W154[x]	59.8 b	6.0 cd	0.54 c	9.7	28.4	331.2
W13	94.1 a	5.1 cd	0.48 c	9.4	28.1	333.5
Mazzard	94.7 a	0.8 d	0.10 c	9.5	28.2	314.8
Significance				*n.s.*	*n.s.*	*n.s.*

[z] Mean separation by SAS LSMeans procedure ($P < 0.05$).
[y] Estimated from the number of buckets harvested per tree (1 bucket = 23 lbs). Harvest was on July 8.
[x] Rootstocks that were discontinued in 2001 due to poor performance or sensitivity to virus.

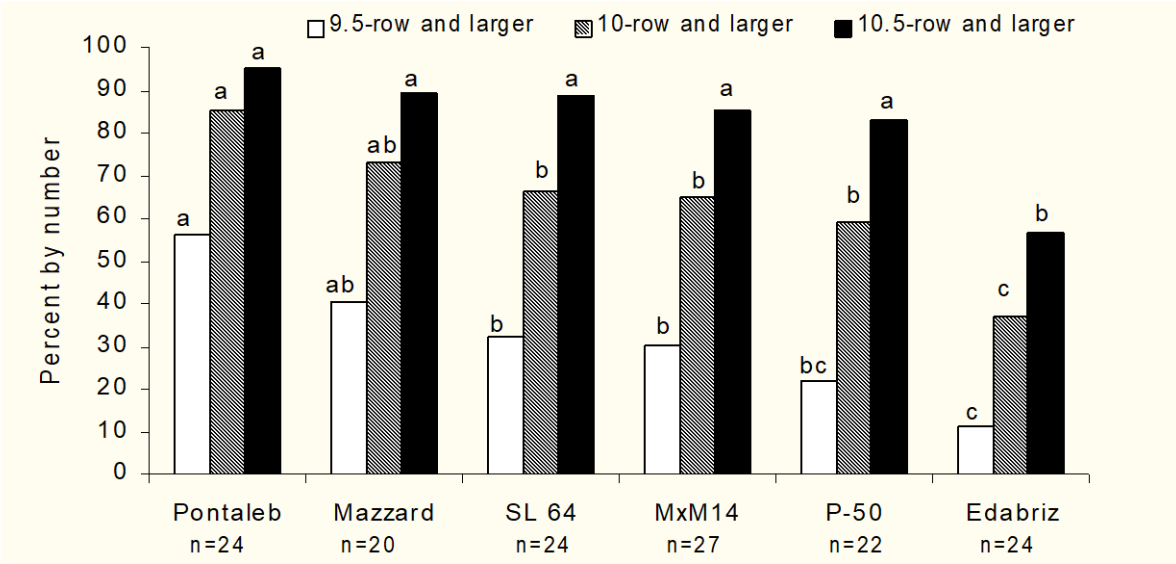

Fig. 1. Row-size distribution for fruit of 'Bing' sweet cherry grafted onto different rootstocks in Hazel Dell (French section). Mean separation within row-size category (not within rootstock) by SAS LSMeans ($P<0.05$). The Dalles, 2001.

Table 2. NC-140 rootstock trial, Orchard View Farms, The Dalles, 2001.

Rootstock	No. of trees[z]	TCSA (cm^2)[z]	Yield (lbs/tree)[z]	Fruit wt. (g)[z]	No. of trees.[y]	cm of branch length[y] # Flwr. buds	cm of branch length[y] # Fruit	# fruit/ flwr bud[y]
Giessen 195-20	6	74.8 de[x]	42.3 a	8.4 bcd	5	1.6 ab	2.7 abc	1.6
Gisela 4	6	53.8 fgh	37.3 ab	6.4 e	5	1.6 ab	3.4 ab	2.1
Gisela 7	6	66.6 ef	35.5 ab	8.2 cd	5	1.5 abc	3.4 ab	2.3
Weiroot 158	5	83.1 cd	30.4 b	8.7 abcd	3	1.2 abcd	2.5 abc	2.0
Weiroot 72	6	51.1 gh	30.4 b	8.5 bcd	3	1.5 abc	3.5 ab	2.4
Gisela 6	8	93.6 bc	29.9 b	9.9 a	7	0.85 cdef	1.5 cde	1.9
Gisela 5	6	66.6 ef	28.4 b	9.5 ab	5	0.91 cdef	2.0 bcde	2.1
Edabriz	5	61.5 efg	28.3 b	8.1 cd	4	1.1 bcd	2.1 abcd	1.9
Giessen 209-1	7	39.5 h	26.9 b	8.4 bcd	3	1.9 a	3.8 a	1.8
Weiroot 53	5	44.4 h	26.8 b	7.5 de	5	1.4 abc	3.1 ab	2.1
Giessen 318-17	8	91.8 bc	15.6 c	9.8 a	5	0.62 def	0.76 de	1.2
Weiroot 10	7	99.5 ab	13.8 c	9.1 abc	6	0.43 ef	0.75 de	1.8
Weiroot 154	4	89.3 bcd	10.7 c	9.8 ab	3	0.27 f	0.37 e	1.4
Weiroot 13	7	110.3 a	10.1 c	9.4 abc	4	0.36 ef	0.59 e	1.9
P. mahaleb	7	98.9 ab	9.6 c	9.8 a	6	0.35 f	0.61 e	1.5

[z] Measurements taken at harvest (June 26).
[y] Based on measurements taken before full bloom (March 21-28).
[x] Mean separation by SAS LSMeans ($P < 0.05$).

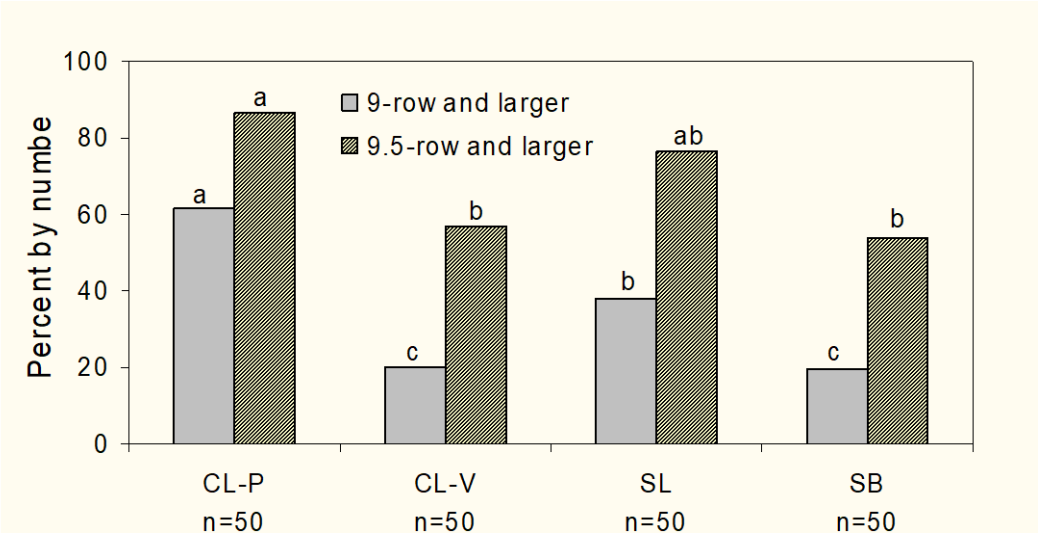

Fig. 2. Row-size distribution for 'Lapins'/Gisela 11 trees as influenced by training system (CL-P = central leader Promalin; CL-V = central leader Vogel; SL = steep leader; SB = Spanish bush). Mean separation within row-size category (not within training system) by SAS LSMeans *(P<0.05)*. MCAREC, Hood River, 2001.

Budg:
Pruning, training, rootstocks, and irrigation management in sweet cherry
Roberto Núñez-Elisea
Project duration: 10 years
Current year: 2002
Original budget request:

Year	Year 1 (2001)	**Year 2 (2002)**	Year 3 (2003)
Total	$36,500	**$39,500**	$41,000

Current year breakdown:

Item	Year 1 (2001)	**Year 2 (2002)**	Year 3 (2003)
Salaries (Res. Assist.)		**$27,739**	
OPE (42.4%)		**$11,761**	
Service and supplies			
Travel			
Total	$36,500	**$39,500**	$41,000

CONTINUING PROJECT **YEAR 11**

Title: Cherry cultivars, rootstocks and production systems

Project leaders: Anita Nina Azarenko
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Oregon State University, 4017 ALS
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Research assistant: Ann Chozinski, Department of Horticulture, Oregon State University

Cooperators:
- Dr. Roberto Nunez-Elisea, MCAREC, Oregon State University
- Mr. Don Nusom, Nusom Orchards, Gervais, OR
- Dr. Frank Kappel, Agriculture Canada, Summerland, BC
- Dr. Robert Anderson, Cornell University, Geneva, NY

Funding History:
Year initiated: 1990
Funding in 2001-2002: $25,509
Funding requested for 2002-2003: $33,475

Objectives:
1. Identify cherry cultivars suitable for the processing cherry industry (e.g. brine, freezer) and those that may have potential for fresh market production in the Willamette Valley.
2. Evaluate cherry genotypes for *Pseudomonas* tolerance.
3. Evaluate new potential rootstocks for commercial acceptability in Willamette Valley cherry production systems.

Evaluate the influence of horticultural techniques and their time if application on branch angle, precocity, production, fruit size and quality, and the presence of bacterial canker. Techniques to be studied include: notching, disbudding/shoot removal, and branch bending.

Significant Findings:
1996 Dark cherry cultivar trial- This trial consists of 17 selections/cultivars from Dr. Frank Kappel's Agriculture Canada cherry breeding program, 'Regina' and 'Bing'. Three trees per genotype are grafted onto Mazzard rootstock and trained to a central leader training system. Three additional selections were planted in 1997. A similar planting is located at a grower site provided by Mr. Don Nusom. Trees have attained the desired height and have filled their allotted space. 'Staccato' began blooming the earliest in the trial, on 31 March, while the latest blooming genotypes included 'Cristalina', 'Sandra Rose', 'Regina', 11W-26-05 and 13S-42-04. Tree vigor and productivity are highly variable across genotypes. The most productive cultivars/selections in 2001 were 'Sylvia', 13S-42-49, 13S-7-40, 13S-49-24, and 'Sandra Rose'. The largest fruit were harvested from 'Symphony', 13S-18-15, 'Sandra Rose', 13N-14-22, and 4W-11-08 trees. 'Bing', 'Sonata', 'Newstar', and 13S-21-07 trees produced the smallest fruit. Less than 10% fruit cracking was observed on 'Sylvia', 'Regina', 13N-14-22, and 13S-21-01.

1998 Blush cherry trial- The trial was planted on 21 April 1998 and consists of 9 selections from Cornell University, NY; 8 BC selections; 'Royal Ann' and 'Sweetheart'. All genotypes were low-budded onto Gisela 5 rootstock. Six replicate trees are planted for each genotype. Trees are being

trained as a central leader. Peak bloom dates were separated by 2 ½ weeks and ranged from 9 April to 25 April for the different genotypes.
Yields ranged from 0.1 kg to as high as 11.2 kg per tree. Fruit size ranged from 6.1g to 10.7g. Cherries are being evaluated for their suitability for both the brine industry and potential fresh market production.

2001 Sweet cherry systems/cultivar trial- *Higher density planting: Gisela 6, Gi196-4 and Maxma14 were low-budded with 'Sweetheart', 13N-07-70, and 'Royal Ann' in September 2001 by Columbia Basin Nursery.*
Low-density top-worked planting: Liners of Gisela 6, Maxma14, MxM60 and Mazzard seedling are being grown for planting in spring 2002.

2000 Branch angle trial- 'Regina' trees grafted onto Mazzard rootstock, that were planted in 1999, are being used in this trial. Four replicate trees received one of four branch angle treatments; 30°, 45°, 60° and 90° from the vertical central leader. Three to four scaffolds per tree were trained to these angles. As branch angle increased, the amount of shoot extension and the number of shoots originating from the trained scaffolds decreased.

Bacterial canker tolerance- *The assay that was developed by Meg Roche, graduate student, is an effective tool for evaluating genotype tolerance to the bacterial canker organism. MxM14 and 39; Giessen 196-4 and 195-20, Gisela 6, 8, 4 and 12; and four PiKu selections exhibited good tolerance to* Pseudomonas syringae.

1995 Gisela rootstock trial- Eight replicate trees each of Gisela 1, 5, 6, 7, 8 and 11 were planted in 1995. In 1997 and 1998, rootstocks were top-worked with two bud grafts of 'Royal Ann'. 'Sweetheart' was top-worked onto F12/1 in 1998 as a pollinizer. Mazzard and Gisela 1 had the lowest yields in 2001. Gisela 5, 7, and 11trees produced the highest and similar yields. The trunk-cross sectional area of Mazzard was more than twice as large as Gisela 1 to ~5 times greater than Gisela 6. Fruit size was largest on Gisela 7 and smallest on Mazzard and Gisela 8. Gisela 6 and 8 had the highest number of suckers.

1998 NC-140 'Bing' rootstock trial- Eight replicate trees each of 'Bing' growing on seven Giessen and six Weiroot selections, Edabriz, Mahaleb, and Mazzard rootstocks were planted 21 April 1998. The trees were planted at a 12' x 16' spacing and are being trained to a central leader. Suckering is high on Gisela 4, Gisela 7, W13, W154, W10 and W158. First bloom was spread over a period of 8 days. The most productive rootstocks were Gisela 7, Gisela 6, Gi 209-1, and Gi 195-20. Fruit size ranged from 7.9 g from trees on Mazzard rootstock to 9.1g from trees on Gisela 6 rootstock. Fruit cracking in this trial ranged from 15-54% and rootstock had a significant effect.

1998 Weiroot rootstock trial- The Weiroot rootstocks; 10, 13, 53, 154, and 158, had 3-5 major scaffolds top-worked with 'Sweetheart' scionwood in May 2000. Gi5 and Mazzard were planted as controls. W154 produced the greatest number of suckers. No fruit were harvested this year.

2000 MxM rootstock trial- The MxM rootstocks; 2, 14, 39, 46, and 60 were planted at an 18' x 18' spacing during Fall 2000. Rootstocks grew well and will be grafted over to 'Sweetheart' in spring 2002.

1998 Budding height trial- 'Royal Ann' was budded onto Gisela 5 at 3 different heights- 12", 24", and 36". Trees have completed their second growing season. The overgrowth of the graft union increases as the budding height increases.

1999 Interstem trial- The interstem trial was planted in September 1999. The trial consists of Gisela 5 and MxM60 rootstocks where they were either grafted high or low (with the scion cultivar 'Royal Ann'), or the rootstocks were used as reciprocal interstems. Shoot number was highest on trees that were low-grafted onto Gisela 5. However, there was no statistical difference in total shoot length between the different combinations. TCSA is smallest for low grafted Gisela 5 and the MxM60 interstem/Gisela 5 rootstock combination trees.

2001 'Lapins' notching trial- Notches were cut above four buds on the central of leaders of 'Lapins' trees that were grafted onto Gisela 6 rootstocks. Leaders were notched on 26 March, 2 April, 16 April, 20 April, or 28 May to determine the effect on the degree of budbreak, shoot length and branch angle. After 16 April (about 2 ½ weeks after budbreak), there is a decline in the number of buds that break to less than one of four. As time of notching was delayed, branch angle increased. Mean shoot length also decreased.

2001 'Lapins' disbudding/shoot removal trial- Four to five buds or shoots were removed from the apical most portion of the central leader and four scaffold limbs leaving the terminal bud intact. Treatments were applied during late winter dormancy, at budbreak, beginning of May, beginning of June and at the end of July. Between budbreak and the beginning of May there was a significant reduction in the number of shoots that broke below the disbudding treatment. As treatments were applied later, the shoot angle increased.

Procedures and Methods:

1. Train, maintain and obtain data on yield, fruit size, tree vigor and other relevant data from the existing cherry cultivar trials which include:

1996 BC dark cherry trial (0.15 ha of low-budded central leader trees)(remove in 2002)

1998 Blush cherry trial (0.35 ha of low-budded central leader trees)(three more years)

2. Each planting will include four replicates of three trees of each cultivar, rootstock, and training system combination.
   Top-worked trees: The rootstocks in the top-worked low-density trial are: Gi196-4, MxM14, MxM 60 and Mazzard seedling. 'Royal Ann', 'Sweetheart' and 13N-07-70 will be top-worked onto these rootstocks. The training systems we will apply in this trial include: free standing, top-worked trees that are trained to a multiple leader tree and central leader (single multiple bud graft) trees. The top-worked trees are to be planted at 18' x 18', in anticipation of mechanical harvest. The total number of trees in this planting will be 288 (0.90 ha). Rootstocks were lined out in a nursery row in Spring 2001. Rootstocks will be dug and planted in Spring 2002. Trees will be top-worked in 2003.

   Low-budded- The low-budded high density trial includes Gisela 6, Gi196-4, and MxM14 rootstocks. The training systems included in this trial are 1) free standing, multiple leader, 2) free standing, central leader trees, and 3) a single wire trellis, central leader tree. This second planting will be planted at 10' x 16'. The total number of trees planted would be 324 trees (0.50 ha). Meadowlake Nursery did not successfully propagate these trees. Columbia Basin Nursery is propagating these for us.

3. Continue to identify and secure for evaluation potential new, late ripening, self-fertile selections suitable for the processing cherry industry and potential fresh market in the Willamette Valley.

4. Continue to evaluate rootstock and cherry cultivars for *Pseudomonas* tolerance. Our research was successful in developing a relevant *in vitro* assay for tolerance to this organism. An initial attempt at inoculating field grown leaves with a mix of *Pseudomonas syringae* pv. *syringae* has revealed promise as a tool for evaluating genotypes for tolerance to this pathogen (personal experience and collaboratively with Dr. Frank Kappel). We intend on screening the dark and blush cherry genotypes in the cultivar trials using a leaf assay.

5. Train, maintain and obtain data on yield, fruit size, tree vigor and other relevant data from the existing cherry rootstock trials which include:

   1995 Giessen rootstock trial (0.25 ha of top-worked 'Royal Ann' trees)

   1998 NC-140 cherry rootstock trial (0.50 ha low-budded central leader 'Bing')

   1998 Weiroot rootstock trial (0.20 ha of top-worked 'Sweetheart')

6. Evaluate growth of trees in the budding height trial of 'Royal Ann' on Gisela 5 at 12", 24" and 36" (0.05 ha)

7. Evaluate growth and fruiting of 'Royal Ann' trees in the interstem trial which contains: low-grafted MxM 60, high-grafted MxM 60, low-grafted Gisela 5, high-grafted Gisela 5, Gisela 5 interstem with MxM 60 rootstock, MxM 60 interstem with Gisela 5 rootstock (0.10 ha).

8. Graft and train MxM rootstocks (2, 14, 39, 46, 60) that were planted in fall 2001 for top-working in winter-spring of 2002/2003 with 'Sweetheart'. Six replicate trees will be planted at 18' x 18' spacing for evaluation of suitability for mechanical harvest (0.12 ha).

9. Evaluate a branch angle trial with 'Regina' on Mazzard. Four replicate trees that are being trained to central leader trees have the primary scaffolds trained to one of four branch angles (30°, 45°, 60° and 90° from the vertical central leader.) Trees were planted in the spring of 1999. The initial crotch angle of the primary scaffolds was trained flat with a clothespin. In 2000 and 2001, shoots were trained to their respective angles. Shoot growth was measured at the end of the second growing season, and flowering, yield and fruit size will be assessed over at least a two-year period (0.05 ha).

10. Evaluate for the second year the response of time of notching on 'Lapins' trees (bud-swell, bud-break, bud-break + 2 weeks, bud-break + 4 weeks, bud-break + 8 weeks) for its effect on shoot growth, branch placement, production and the presence of bacterial canker (0.05 ha).

11. Evaluate, for the second year, the influence of the time of disbudding and shoot removal on branch angle, shoot growth of the remaining shoots, and the presence of bacterial canker. Treatments included are: bud removal in the dormant season; and bud/shoot removal at bud-break, bud-break + one week, bud-break + 2 weeks, bud-break + 3 weeks, and bud break + 4 weeks (0.05 ha).

Summary of trials and land use:

Trial	Land use (ha)
1995 Gisela rootstock trial ('Royal Ann')	0.25
1998 NC-140 cherry rootstock trial ('Bing')	0.50
1998 Weiroot rootstock trial ('Sweetheart')	0.20
2000 MxM rootstock trial ('Sweetheart')	0.12
Budding height trial (Gi5 and 'Royal Ann')	0.05
Interstem trial (MxM60, Gi5, and 'Royal Ann')	0.10
1996 BC dark cherry trial	0.15
1998 Blush cherry trial	0.35
2001 Sweet cherry system/cultivar trial (top-worked)	0.90
2001 Sweet cherry system/cultivar trial (low-budded)	0.50
Branch angle ('Regina')	0.05
Time of notching ('Lapins')	0.05
Time of disbudding and shoot removal ('Lapins')	0.05
	3.27

Estimated Duration:
Nine to 10 years from time of planting for the cultivar, rootstock, and production system's trials. Two to three years for the trials on horticultural management tools.

Results and Discussion:
1*996 Dark cherry cultivar trial*- First and peak bloom dates (70% bloom) were recorded in spring 2001 and spanned 3 weeks (Table 1). The most productive cultivars/selections in 2001 were 'Sylvia', 13S-42-49, 13S 17-40, 13S-49-24, and 'Sandra Rose'. Of the trees planted in the same year, the trees with the largest TCSA are 'Newstar', 'Sandra Rose', 8S-03-13, 'Sylvia', 'Symphony', and 13S-49-24. 'Cristalina' had the smallest TCSA. 'Bing' fruit were the smallest along with Newstar, 13S-21-07, and 'Sonata' (7.3-7.9g), while 'Symphony', 'Sandra Rose', 13S 18-15, 13N 14-22, and 4W 11-08 fruit were the largest (10.1-10.8g). A major rain event on 26 June gave us a good indication of cracking tolerance. Less than 10% cracking was observed on 13S 21-01, 'Symphony', 13N 14-22, 'Regina' and 'Sylvia'. With the exception of 'Sylvia', these selections/cultivars ripen relatively late. Although, the late ripening genotype, 8S 03-13, had a high percentage of cracking. Stems were relatively long for 'Regina', 13S 21-01, 'Symphony', 13S 49-24, 8S-03-13, 13S 17-40, and 4W 11-08 with a range from 4.3-5.0cm.

1998 Blush cherry trial- First bloom began on 30 March and continued through 17 April (Table 2). Peak bloom dates ranged from 9-25 April. In the Willamette Valley, later blooming genotypes would be desirable to enhance fruit set because of cool spring temperatures, rainy weather and limited bee activity. 13N 07-39, NY13688, NY307, NY9295, 13S 07-50, NY7855, 13N 07-32, 13N 07-70, 13S 09-37 all bloomed later than 'Royal Ann'. Of these that bloomed relatively late, those that were harvested after 4 July were 13N 07-39, 13N 07-32, 13S 09-37, and 13N 07-70. Fruit weight of these genotypes was quite large and might serve as a niche for a later ripening, fresh market type cherry. (How would these genotypes respond to dryland conditions- would the size be more appropriate for the brine market?) The percent cracking was less than 10% for 13N 07-32 and 13N 07-70. Stem length was relatively long for 13N 07-70.

2001 Sweet cherry systems/cultivar trial- Higher density planting: Gisela 6, Gi196-4 and Maxma14 were low-budded with 'Sweetheart', '13N7-70', and Royal Ann in September 2001 by Columbia

Basin Nursery. Low-density top-worked planting: Liners of Gisela 6, Maxma14, MxM60 and Mazzard seedling are being grown in a nursery row for planting in the orchard in the late winter/early spring 2002 and subsequent top-working with same cultivars mentioned above in the spring of 2003. The ground has been prepared for spring planting in 2002 and 2003.

Bacterial canker tolerance- Maxma14, PiKU 4-22, MxM39, Gi 196-4, PiKU 4-20, Gi195-20, and Gisela 6 develop virtually no symptoms after the inoculation of tissue cultured leaf explants (Figure 1). Conversely, 'Rainier' and 'Corum' express severe symptoms, followed by W53, W158, W154, Gisela 5, Gi 209-1, W10, Mazzard seedling and PiKu1-10. An initial attempt has been made to use field-grown leaves in the assay. Dr. Kappel is evaluating the use of this assay for his breeding program. In the field, six of the nine Cornell blush selections are displaying severe bacterial canker-like symptoms (Table 3). 'Bing' trees on Gi 209-1, Gisela7, and Gisela 5 are also showing similar, severe symptoms.

2000 Branch angle trial- 'Regina' trees grafted onto Mazzard rootstock, that were planted in 1999, received one of four branch angle treatments; 30°, 45°, 60° and 90° from the vertical central leader. As the branch angle increased from the leader, the mean shoot length decreased, as did the number of shoots per scaffold (Table 4). The narrower the branch angle, the longer the mean shoot length was. Flowering spurs will be counted and yield per scaffold will be obtained in the spring.

1995 Gisela rootstock trial- Mazzard and Gisela 1 had the lowest yields in 2001 (Table 5). 'Royal Ann' trees on Gisela 5, 7, and 11 rootstocks produced the highest yields. The trunk cross-sectional area of Mazzard ranged from more than twice as large as Gisela 1 to almost five times greater than Gisela 6. Fruit size was largest on Gisela 1 and smallest on Gisela 6, 8 and 11. Gisela 6 and 8 had the highest number of suckers.

1998 NC-140 'Bing' rootstock trial- Rootstock influenced the time of first bloom by one week and peak bloom only slightly (Table 6). Cropping was good but rain at the end of June caused significant cracking. The most productive genotypes in 2001 were Gisela 7 and 6, and Gi209-1. The lowest yields were obtained from Mahaleb; Mazzard; Weiroot selections 10, 154, and 158; Edabriz; and W53. The trees grafted on Gisela 6, Mazzard, and Weiroot 13, and Weiroot10 have the largest TCSA. The trees with the smallest TCSA were Gisela 4, Weiroot 53, Gi 209-1, Weiroot 72, Gisela 7, Weiroot 154, and 'Edabriz'. Fruit size was greatest on Gisela 6 (9.0g) but only differed significantly from Mahaleb. Suckering was most prevalent for Gisela 4, Gisela7, Weiroot 154, Weiroot 13, Weiroot 10, and Weiroot 158 trees.

1998 Weiroot rootstock trial- The Weiroot rootstocks; 10, 13, 53, 154, and 158 were top-worked onto 3-5 major scaffolds in May 2000 with 'Sweetheart' scionwood. Gisela 5 and Mazzard serve as controls. Weiroot 53 is the smallest tree followed by Weiroot 154 (Table 7). The next group are similar in size and includes Weiroot 158, Gisela 5, and Weiroot 10. Weiroot 13 is more vigorous than this previous group. Mazzard trees have the highest TCSA.

1998 Grafting height trial- 'Royal Ann' was grafted onto Gisela 5 rootstocks at 15, 30 and 60 cm heights to determine the influence of grafted height on tree growth and yield. The TCSA below the graft union at the 15cm height is larger than those at the 30cm and 60cm (Table 8). There is a significant overgrowth of the graft union for all grafting heights with the highest height having the greatest overgrowth.

1998 Interstem trial- Low-grafted Gisela 5 trees produced the greatest number of shoots and Gisela 5 with the MxM60 interstem produced the least (Table 10). Total new growth was not different between the various combinations. However, mean shoot length was much smaller for the low-

grafted Gisela 5. These low grafted Gisela 5 rootstocks also had more vegetative growth relative to its TCSA, a higher vegetative index, than the other combinations.

2001 Time of notching trial- Mean shoot length at the end of the growing season after notching on 26 March, 2 and 16 April of the central leader of 'Lapins' trees on Gisela 5 rootstocks did not differ (Table 10). However, as you delayed notching the branch angle had a tendency to increase. After 16 April, notching did not stimulate an adequate amount of budbreak for central leader trees.

2001 Time of disbudding and shoot removal- The time of removing buds or shoots (4-5) from just below the apical most bud of the central leader greatly influenced the mean shoot length, shoot angle and the number of laterals originating from below the point of disbudding or shoot removal (Tables 11 and 12). Shoot length of lateral branches was only reduced after the June treatment. Branch angle was also increased as the timing was delayed. The number of shoots originating from the central leader decreased after the May and June treatments. No buds broke to form shoots in the postharvest treatment. Similar trends were observed in the treatments applied to the lateral branches. As the treatments were applied later, there was less shoot growth, greater branch angles, and less shoots produced per limb.

Table 1. Harvest and bloom dates, yield, trunk cross-sectional area, yield efficiency, fruit weight, soluble solids, cracking and stem length of cultivars and Agriculture Canada selections grafted onto Mazzard rootstock and planted in 1996.

Rootstock[z]	Harvest date	First bloom	Peak bloom	Yield (kg)	TCSA[y] (cm^2)	Change in TCSA (cm^2)	Yield efficiency (kg/cm^2)	Fruit weight (g)	Soluble solids[w] (°Brix)	Cracking (%)	Stem length (cm)
Newstar[x]	July 4	April 2	April 17	0.9	175.1	94.1	<.01	7.9	25.9	55	4.0
13S 21-07	July 4	April 9	April 18	2.1	122.0	12.1	.02	7.9	23.4	24	3.4
Sonata	July 4	April 5	April 15	4.3	102.5	25.5	.04	7.4	19.9	30	4.4
Bing[v]	July 4	April 3	April 16	1.1	93.7	38.8	.01	7.3	21.5	28	3.9
Sandra Rose	July 5	April 13	April 23	6.1	173.9	27.4	.04	10.2	24.0	18	3.6
13S 49-24	July 5	April 1	April 16	8.4	145.6	52.7	.06	9.4	19.2	27	4.7
13S 17-40	July 5	April 9	April 18	8.8	114.2	24.0	.08	8.9	22.2	35	4.3
Sylvia	July 5	April 14	April 23	15.5	152.3	29.5	.10	8.7	18.0	7	3.8
13S 18-15	July 10	April 2	April 16	1.9	77.0	14.2	.03	10.6	22.9	24	3.1
Regina[v]	July 10	April 17	April 24	2.5	84.5	23.1	.03	8.5	22.7	4	5.0
13N 14-22	July 11	April 6	April 20	0.7	98.1	17.7	.01	10.2	22.6	2	1.8
13S 42-49	July 11	April 15	April 23	12.9	111.5	22.8	.12	9.4	18.5	16	3.5
4W 11-8	July 16	April 12	April 21	4.6	120.1	24.2	.04	10.1	20.5	14	4.4
Symphony	July 25	April 1	April 16	0.5	146.2	38.5	<.01	10.8	21.7	8	4.7
13S 21-01[x]	July 25	April 6	April 18	0.1	99.0	19.6	.01	8.5	21.6	1	5.0
Cristalina	July 28	April 13	April 23	3.3	82.5	25.4	.04	9.2	18.9	20	4.0
8S 03-13	July 30	April 5	April 16	0.8	166.8	30.1	.01	9.8	21.3	66	4.5
Staccato[x, v]	n/a	March 31	April 14	0.2	109.7	n/a	<.00	n/a	n/a	n/a	n/a
11W 26-58[x, v]	n/a	April 15	April 23	n/a	67.3	n/a	n/a	n/a	n/a	n/a	n/a
13S 16-29[x, v]	n/a	April 14	April 23	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
MSD		3.9 days	2.1 days	3.1	43.0	34.0	.03	4.7	6.3	23	1.1

[z]Means separation by Waller-Duncan k-ratio t-test, k-ratio = 100.
[y]TCSA = trunk cross-sectional area in September 2001.
[x]Heavy raccoon pressure caused low yields.
[w]Composite sample of 50 fruit.
[v]Planted one year later.

Table 2. Harvest and bloom dates, yield, trunk cross-sectional area, yield efficiency, fruit weight, soluble solids, cracking and stem length of cultivars and blush selections grafted onto Gisela 5 rootstock and planted in 1998.

Rootstock[z]	First bloom	Peak bloom	Harvest date	Yield (kg)	TCSA[y] (cm^2)	Change in TCSA (cm^2)	Yield efficiency (kg/cm^2)	Fruit weight[x] (g)	Soluble solids[w] (°Brix)	Cracking (%)	Stem length (cm)
NY518	March 30	April 9	June 29	1.7	53.8	21.8	.03	6.1	18.5	13	5.3
NY252	March 30	April 14	July 2	3.7	55.2	21.8	.07	8.4	18.2	3	5.1
NY7690	March 31	April 16	July 3	0.1	63.8	25.6	<.01	9.6	18.9	8	1.3
2N 31-19	March 31	April 13	July 13	1.1	46.0	20.0	.02	9.0	17.6	2	3.7
Sweetheart	March 31	April 15	July 15	2.4	56.0	23.2	.04	8.2	19.6	<1	4.0
13S 21-14	April 3	April 15	July 13	1.7	36.4	12.9	.05	8.3	18.3	<1	n/a
NY6091	April 3	April 17	July 3	0.2	58.8	24.7	<.01	8.0	n/a	2	n/a
13S 20-11	April 3	April 16	July 13	1.1	44.8	18.7	.02	7.8	19.9	<1	2.4
Royal Ann	April 3	April 18	July 3	7.0	63.4	24.1	.11	8.4	19.4	3	n/a
NY8182	April 4	April 19	July 3	8.9	50.0	19.0	.18	7.4	19.1	5	n/a
13N 07-39	April 9	April 21	July 9	11.2	58.8	21.7	.19	9.1	19.7	20	4.2
NY13688	April 13	April 21	July 3	7.2	45.3	17.9	.16	8.5	18.6	40	n/a
NY307	April 13	April 23	July 3	1.2	56.9	22.1	.02	10.0	18.6	6	3.9
NY9295	April 13	April 23	July 3	5.8	55.8	21.1	.10	8.2	19.1	6	4.9
13S 07-50	April 14	April 22	July 3	0.7	35.3	13.4	.02	7.6	20.1	82	n/a
NY7855	April 14	April 23	July 3	4.7	45.4	18.2	.10	9.0	19.6	6	4.7
13N 07-32	April 16	April 24	July 6	1.6	46.8	19.1	.03	10.7	18.5	9	3.6
13N 07-70	April 16	April 25	July 13	6.4	49.0	17.7	.13	9.8	20.4	3	4.8
13S 09-37	April 17	April 24	July 9	3.3	46.4	18.8	.06	9.9	20.1	38	4.2
MSD	1.7 days	1.5 days	<1 day	2.6	8.2	5.4	.05	0.8	1.6	10	2.0

[z]Means separation by Waller-Duncan k-ratio t-test, k-ratio = 100.
[y]TCSA = trunk cross-sectional area in September 2001.
[w]Composite sample of 50 fruit.
[x]Mean of 50 fruit.

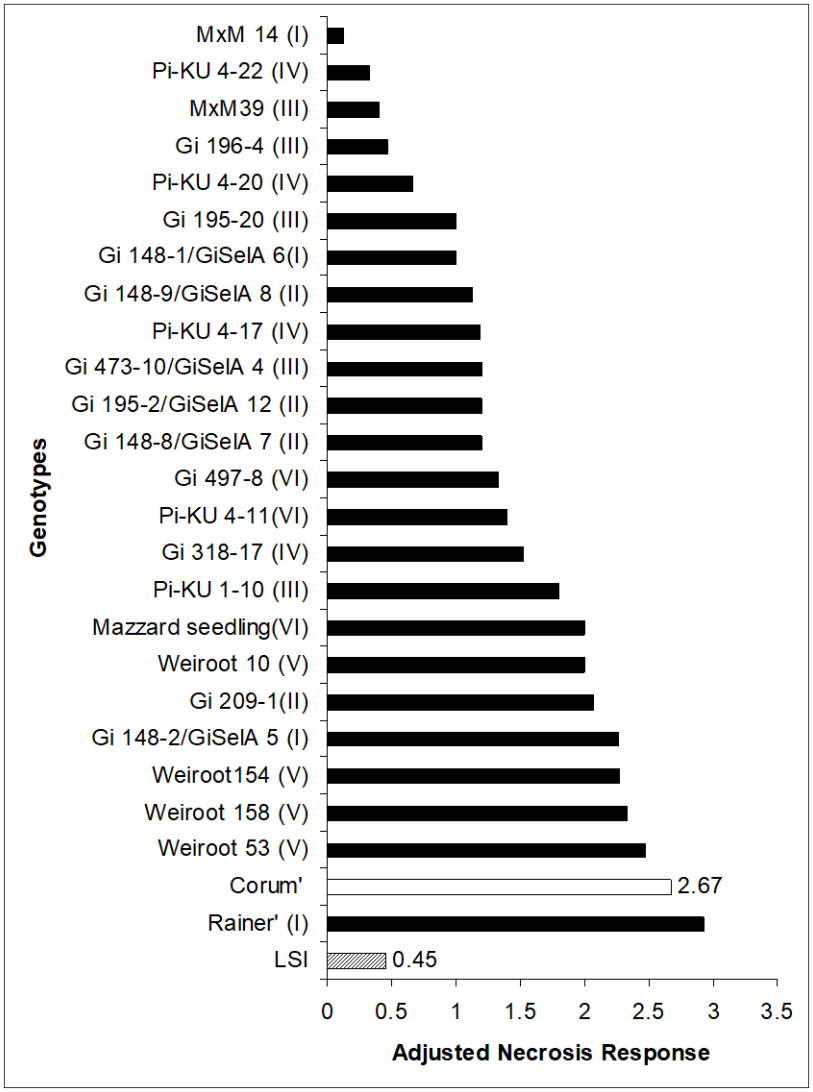

Figure 1. The response of tissue cultured leaves to inoculation by a mixture of three virulent *Pseudomonas syringae* pv. *syringae* strains at 10^8 colony forming units. Leaves were rated one week after inoculation. The infection rating was 0-4; where 0= no visible symptoms, 1= distinct chlorotic lesion that is restricted to the midrib, 2= distinct chlorotic/necrotic lesion that is not restricted to the midrib but does not exceed 50% of the leaf area, 3= same as 2 but exceeds 50% of the leaf area, and 4= chlorosis/necrosis covers the entire leaf.

Table 3. Field incidence of bacterial canker-like symptoms in the blush and NC140 'Bing' rootstock trial in 2001.

Blush genotypes	Mild	Moderate	Severe	NC140 rootstocks	Mild	Moderate	Severe
NY 6091	2	1	3	209-1		2	1
Sweetheart		2	2	Gi 7 (148-8)		1	1
NY 7690	1		2	Gi 5 (148-2)	1		1
13S 21-14			2	Gi 6 (148-1)		1	
NY 518		2	1	W10	1		
NY 8182		1	1	Mazzard	1		
NY 9295			1	W158	1		
NY 307			1	W13	1		
2N 31-19	1	1		W72	1		
Royal Ann		1		Edabriz			
13S 20-11	1			Gi 195-20			
13S 07-50	2			W154			
NY 252	2			W 53			
13N 07-39				Gi 318-17			
NY 13688				Mahaleb			
NY 7855				Gi 4 (473-10)			
13N 07-32							
13N 07-70							
13S 09-37							

Number of trees from 6 replicates.

Table 4. Shoot length, number of shoots and shoot length per scaffold of 'Regina' trees where primary scaffolds were trained to a range of different branch angles.

Branch angle from leader	Shoot length[z] (cm)	No. of shoots per scaffold	Shoot length/scaffold (cm)
90	52.4	1.8	53.3
60	63.2	2.6	60.0
45	70.7	4.4	70.4
30	78.3	4.1	80.0
MSD	12.7	0.8	6.4

[z]***Means separation by Waller-Duncan k-ratio t-test, k-ratio = 100.***

Table 5. Influence of Gisela rootstocks on bloom time, yield, trunk cross-sectional area, yield efficiency, fruit weight, soluble solids concentration and suckering of top-worked 'Royal Ann' trees.

Rootstock[z]	First bloom	Peak bloom	Yield (kg)	TCSA[y] (cm^2)	Change in TCSA (cm^2)	Yield efficiency (kg/cm^2)	Fruit weight (g)	Soluble solids (°Brix)	Sucker rating[x] (0-4)
Gisela 1 (172-9)	April 3	April 18	7.0	128.4	32.1	.09	6.9	17.9	0.9
Gisela 11 (195-1)	April 3	April 19	26.1	76.6	14.2	.34	5.7	16.3	1.1
Mazzard	April 3	April 17	4.3	271.8	84.5	.02	6.4	17.8	0.9
Gisela 5 (148-2)	April 5	April 19	27.4	70.8	11.1	.39	6.1	16.9	0.1
Gisela 7 (148-8)	April 5	April 20	27.2	69.0	16.7	.40	5.8	16.5	0.8
Gisela 6 (148-1)	April 6	April 19	20.7	57.4	9.0	.36	5.6	16.3	2.5
Gisela 8 (148-9)	April 6	April 20	19.7	62.2	8.8	.33	5.6	16.7	2.0
MSD	2.4 days	2.0 days	4.4	24.7	9.1	.08	0.4	0.7	0.9

[z]Means separation by Waller-Duncan k-ratio t-test, k-ratio = 100.
[y]TCSA = trunk cross-sectional area in September 2001.
[x]Sucker rating: 0 = no suckers, 1 = 1-10 suckers, 2 = 11-20 suckers, 3 = 21-30 suckers, 4 = 30+.

Table 6. Bloom dates, yield, trunk cross-sectional area, yield efficiency, fruit weight, soluble solids, fruit cracking, and suckering of 'Bing' trees planted in the 1998 NC-140 rootstock trial at the Lewis-Brown Research Farm, Corvallis, OR. Fruit were harvested on 2 July 2001.

Rootstock[z]	First bloom	Peak bloom	Yield (kg)	TCSA[y] (cm^2)	Change in TCSA (cm^2)	Yield efficiency (kg/cm^2)	Fruit Weight (g)	Soluble solids[w] (°Brix)	Cracking (%)	Sucker rating[x] (0-4)
Gi 4 (473-10)	March 31	April 16	4.8	49.0	19.0	.10	8.9	20.9	54	3.4
W 53	April 3	April 18	3.8	51.6	20.6	.08	8.7	21.5	35	1.9
Gi 209-1	March 31	April 17	5.1	53.5	20.7	.10	8.8	20.3	30	1.3
W 72	April 3	April 17	4.3	55.9	23.3	.08	8.8	20.4	38	1.9
Gi 7 (148-8)	April 2	April 18	6.9	62.1	23.5	.11	8.9	18.7	29	3.1
W 154	April 5	April 16	2.4	62.8	28.2	.04	8.6	20.7	32	2.8
Edabriz	April 3	April 17	3.3	63.9	28.2	.05	8.9	19.9	29	1.4
Gi 5 (148-2)	April 1	April 17	4.8	68.4	26.3	.07	9.0	19.9	29	1.1
Mahaleb	April 3	April 16	2.0	75.7	34.1	.03	8.1	21.1	27	1.6
Gi 318-17	April 3	April 17	4.1	80.4	34.5	.05	8.7	18.7	15	1.7
Gi 195-20	April 2	April 18	5.0	80.6	34.3	.06	8.4	19.2	26	1.0
W 158	April 5	April 17	3.1	82.2	38.2	.04	8.9	20.2	33	2.4
W 10	April 5	April 17	2.5	85.3	37.4	.03	8.5	20.2	29	2.5
W 13	April 4	April 16	3.2	88.7	36.9	.04	8.7	18.8	20	2.9
Mazzard	April 7	April 17	2.2	94.3	40.0	.03	7.9	19.7	19	1.5
Gi 6 (148-1)	April 2	April 17	6.5	97.6	41.5	.07	9.1	18.9	19	1.1
MSD	2.3 days	1.7 days	1.8	14.9	7.6	.03	0.8	2.3	24	0.7

[z]Means separation by Waller-Duncan k-ratio t-test, k-ratio = 100.
[y]TCSA = trunk cross-sectional area in September 2001.
[x]Sucker rating: 0 = no suckers, 1 = 1-10 suckers, 2 = 11-20 suckers, 3 = 21-30 suckers, 4=30+.
[w]Composite sample of 50 fruit.

Table 7. The influence of top-worked Weiroot rootstocks on the TCSA and suckering of 'Sweetheart' trees. Trees were top-worked in spring 2000.

Rootstock[z]	TCSA[y] (cm^2)	Change in TCSA (cm^2)	Sucker rating[x] (0-4)
W53	9.3	2.6	1.0
W154	11.5	3.5	1.5
W158	28.1	5.6	0.8
Gi 5	30.1	5.1	0.2
W10	33.6	5.9	1.0
W13	37.9	5.7	0.8
Mazzard	83.7	10.5	1.0
MSD	6.2	0.8	0.5

[z]Means separation by Waller-Duncan k-ratio t-test, k-ratio = 100.
[y]TCSA = trunk cross-sectional area in September 2001.
[x]Sucker rating: 0 = no suckers, 1 = 1-10 suckers, 2 = 11-20 suckers, 3 = 21-30 suckers, 4 = 30+.

Table 8. The influence of budding height of 'Royal Ann' onto Gisela 5 rootstock on yield, fruit size, fruit cracking, and the overgrowth of the graft union. Trees were grafted in 1998.

Budding height (cm)	TCSA[z, y] (cm^2) 10 cm above graft	TCSA (cm^2) 10 cm below graft	TCSA ratio[x]
15	46.9	28.5	1.7
30	41.1	20.5	2.0
60	58.0	21.7	2.7
MSD	9.4	0.2	.31

[z]Means separation by Waller-Duncan k-ratio t-test, k-ratio = 100.
[y]TCSA = trunk cross-sectional area in September 2001.
[x]Ratio of TCSA at 10 cm above graft :TCSA at 10 cm below graft union.

Table 9. The influence of the grafting height of MxM60 and Gisela 5, and MxM60 and Gisela 5 interstems on shoot number, shoot length, TCSA, and the vegetative index. Trees were planted in spring 2000.

Budding and interstem combination	Current growth (# of shoots) [z]	Total length (m)	Shoot length (cm)	TCSA[y] (cm^2)	Change in TCSA (cm^2)	Vegetative index[x]
MXM60 interstem / Gi 5 rootstock	9.0	0.9	94	12.9	9.5	64.8
High grafted Gi 5	11.7	0.9	76	13.1	8.9	66.4
High grafted MXM60 rootstock	12.1	1.2	99	18.6	13.8	64.8
Low grafted MXM60 rootstock	12.1	1.2	101	18.5	13.8	65.5
Gi 5 interstem / MXM60 rootstock	12.4	0.9	75	14.5	9.8	61.5
Low grafted Gi 5	17.7	1.0	56	12.7	9.1	77.0
MSD	4.4	0.4	19	5.4	3.8	15.1

[z]Means separation by Waller-Duncan k-ratio t-test, k-ratio = 100.
[y]TCSA = trunk cross-sectional area in September 2001.
[x]Vegetative index=total shoot length/TCSA.

Table 10. The influence of time of notching on shoot length, angle and number from the central leader of 'Lapins' cherry trees that are grafted onto Gisela 5 rootstock. Four notches were made on each leader.

Notching date	Shoot length[z] (cm)	Shoot angle (°)	Shoot number/ leader
March 26	77.7	53.3	4.0
April 2	68.2	56.7	3.0
April 16	66.7	61.2	2.3
April 30	47.0	65.0	0.3
May 28	n/a	n/a	0.0
MSD	16.4	18.7	1.8

[z]Means separation by Waller-Duncan k-ratio t-test, k-ratio = 100.

Table 11. The influence of the time of disbudding or shoot removal in 2001 on shoot length, angle, and number from the central leader of 'Lapins' trees grafted onto Gisela 5 rootstocks.

Disbudding/shoot removal date	Shoot length[z] (cm)	Shoot angle (º)	Shoot number/ lateral
Dormant	92.5	48.6	5.5
Budbreak	85.3	50.7	4.7
May	101.0	54.0	1.7
June	32.0	63.8	2.0
Post harvest	3.0	65.0	0.0
MSD	41.6	21.2	2.7

[z]Means separation by Waller-Duncan k-ratio t-test, k-ratio = 100.

Table 12. The influence of the time of disbudding or shoot removal in 2001 on shoot length, angle, and number on three to four one-year old laterals of 'Lapins' trees grafted onto Gisela 5 rootstocks.

Disbudding/shoot removal date	Shoot length[z] (cm)	Shoot angle (º)	Shoot number/ lateral
Dormant	80.2	45.7	3.1
Budbreak	81.7	53.3	2.9
May	23.6	62.5	0.3
June	78.0	75.0	0.3
Post harvest	28.2	62.4	2.1
MSD	22.4	11.6	0.8

[z]Means separation by Waller-Duncan k-ratio t-test, k-ratio = 100.

Budget Requested:
Cherry cultivars, rootstocks and production systems
Anita Nina Azarenko

Project duration: Continuous
Current year: 2002
Original budget request:

Year	**2001**	**2002**
Total	$25,509	**$33,475**

Item		
Salaries	$7,800	**$13,656**
Benefits (%)	4,914	**7,374**
Wages	3,900	**3,900**
Benefits (%)	195	**195**
Equipment		**2,000**
Supplies	2,500	
Travel	500	**464**
Miscellaneous		
Plot charges	5,700	**5,886**
Total	**$25,509**	**$33,475**

CONTINUING PROJECT **YEAR 2**

PROJECT NO.: CH-01-16 (13C-3355-5202)

TITLE: Intensive Sweet Cherry Orchard Management

Principal Investigators: Matthew Whiting
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J. Kelly, Pasco, WA
S. Gay, Pasco, WA

YR INITIATED: 2001-02 **CURRENT YR:** 2002-03 **TERMINATING YR:** 2003-04

OBJECTIVES:
Comprehensive orchard management research is necessarily a long-term project. However, various components of the objectives will be completed annually.

1. Refine high density orchard management techniques (e.g., pruning/training systems) for 'Bing' and 'Rainier' trees established in 1995 on dwarfing and non-dwarfing rootstocks. Remaining trial duration is two to three years.

2. Continue to evaluate the interactions between high density pruning/training systems and trees on various rootstocks for precocity, yield efficiency, fruit quality and other horticultural characteristics. Remaining trial duration is two to three years.

3. Develop and apply cultural techniques, such as developmental bud and branch management, growth regulator applications, deficit irrigation, etc. to achieve smaller trees on non-dwarfing rootstocks in new WSU or cooperators' orchards. Trials are monitored for two to three years.

4. Develop and evaluate experimental management practices (e.g., pruning strategies and growth regulator applications) that facilitate mechanical harvest for future application to intensive management strategies.

Significant findings:
Summer Pruning:
Summer pruning was initiated one week after the 1999 harvest of 'Bing' cherries on Gisela 5 rootstocks in Prosser. All one-year wood was headed in order to remove some fruit bearing surface as well as to promote vegetative growth. Sets of trees were pruned at intervals of three to four days, at nine timings to determine if there was an optimum period for summer pruning. Pruning began July 7 and ended Aug 9. Trees pruned between July 7 and 22 produced some shoot regrowth in 1999 after pruning. In addition, several flower buds below the cut dropped on shoots producing new shoots. In the following season, shoot growth, fruit firmness, soluble solids, and fruit size were greater on trees pruned after July 26. In addition, all summer pruned trees produced larger and higher quality fruit than on trees pruned moderately during dormancy. Fruit quality appears higher when trees are pruned

between July 26 and August 2, approximately 25-30 days after harvest. This correlates well with the period in which floral buds are differentiating and terminal bud set on new shoots.

Urea Project:
An experiment was conducted in the summer of 1999 to stimulate postharvest shoot growth and examine whether the encouragement of shoot growth during floral bud initiation might reduce overall crop load (a desirable effect on Gisela rootstocks). Urea was applied to Gisela 7 rootstocks as foliar spray, using weekly and biweekly treatments beginning four weeks prior to harvest and ceasing eight weeks after harvest. Concentrations ranged from 40-80 pounds urea per tank. Sprays were used as a supplemental supply of nitrogen. Pre-harvest nitrogen applications had no effect on soluble solids or fruit firmness, although fruit weight was greater when weekly applications of 80 lbs urea were used. Shoot lengths at the end of the season were also greater, indicating an increase in total leaf area after nitrogen was applied. Fruit size, quality and vegetative growth were similar between all treatments in the season following nitrogen treatment.

Growth Regulators:
Research by Don Elfving investigated the growth regulating possibilities of Apogee™ and Ethrel™ applied separately and in combination on 'Attika', 'Bing', and 'Regina' cultivars. Results clearly illustrated the short term nature of the control effects of both products and point clearly to the need for some sort of retreatment schedule to sustain control of growth over our very long growing season. In 2001, fourth-leaf trees of 'Attika', 'Bing' and 'Regina' on Mazzard rootstock in the same orchard were treated twice over a 3-week interval with P-Ca, ETH or the tank mix. P-Ca alone slowed shoot growth in 'Attika' and 'Bing' for several weeks after treatment but did not reduce overall growth. ETH alone reduced both shoot growth rate and total shoot growth. In both cultivars, the tank mix produced a strong, synergistic reduction in shoot growth. In contrast, 'Regina' shoot growth was reduced only by ETH regardless of the presence or absence of P-Ca.

Cultivar x Rootstock x Training System:
In 2001 we compared vegetative characteristics and fruit quality of 'Bing' trained to 4 distinct systems: the free-standing central leader (cone) and spanish bush with the trellised palmette, and Y-trellis.

- Among training system and across rootstocks:
  - there were no differences in fruit quality among training systems in 2001
  - Y-trellis yield was significantly higher than central leader and palmette
  - trees trained to central leader and palmette systems were the least vigorous
  - yield efficiency (kg/cm^2) was similar for all training systems

- Among rootstocks and across training system:
  - fruit quality was best on Mazzard and similar on Gisela 5 and 6
  - yield was highest on Gisela 6 and lowest on Mazzard
  - Mazzard was the most vigorous followed by Gisela 6 and Gisela 5
  - yield efficiency was greatest and similar on Gisela rootstocks and significantly less on Mazzard

- Across all rootstock/training system combinations, yield efficiency and fruit size were correlated closely (r^2=0.83) and negatively

Methods:
A 4-acre (2ha) high density orchard (360tress/acre) of 'Bing' and 'Rainier' on Mazzard (full size), and Gisela 5 (50% size), Gisela 6 (Full size), Gisela 7 (55% size), and Gisela 11 (75% size) was established in 1995 at WSU-Prosser's Roza Experimental Unit with microsprinkler irrigation and wind machine frost protection. Eight training systems, four trellised (single-plane palmette, double-plane "Y", single-plane oblique leader, and single-plane central leader) and four self supporting (multiple leader bush, central leader spindle, central leader axe, and standard multiple leader), were imposed in a randomized block design. Size control, precocity, yield efficiency, fruit quality and other horticultural characteristics are being evaluated relative to both rootstock/scion combinations and rootstock/training system interactions.

Several smaller high density orchards have been planted at the Roza Experimental Unit for short-term studies of specific intensive management practices as trees have been available. These include: 'Bing' and 'Rainier' on Mazzard and Gisela 5, Gisela 6, Gisela 7, and Gisela 11 rootstocks, planted in 1995 on a single plane trellis at trunk anglesthat vary by 15° increments from 30° to 90°, to examine specific training vs. cropping responses (precocity, fruit quality, and flower bud development vs. shoot growth); a very high density orchard of 'Bing' on Gisela 1 (GI 172/9), planted in 1996 and trained to a central leader spindle to examine canopy architecture as influenced by selected bud or shoot removal, as well as renewal pruning on fruit quality since Gisela 1 is prone to severe overcropping and poor vigor; and high density orchard plots of 'Chelan', 'Attika', 'Lapins', and 'Regina' planted in 1998 on standard rootstocks and trained to either a multiple leader bush or central leader spindle training system to examine growth and precocity responses of these new cultivars to high density training systems. Selective bud removal strategies on young trees in these, and in grower/cooperator orchards will continue to examine the potential for non-Promalin branch development, enhancement of precocity on standard rootstocks, and balancing of reproductive vs. vegetative vigor on precocious rootstocks. These orchards are also available for future studies of mechanical harvest efficiency, orchard covering strategies, or other intensive management techniques as industry interest warrants.

Results and Discussion:
As sweet cherry production continues to evolve toward higher density planting systems, effective orchard trials are needed to better understand key components (*e.g.*, cultivar, rootstock, and training system and their interactions). This project provides critical, practical information relating sweet cherry cropping performance to specific intensive training and orchard management decisions under PNW conditions. In addition, as project orchards mature, the increased feasibility and potential impact of unique production strategies, such as mechanical harvest will be documented.

Our results suggest that training system *per se* has little affect on sweet cherry yield and quality (Table 1). However, trees trained to Y-trellis out-yielded other architectures while maintaining similar fruit quality. Future research needs to focus on specific management techniques (*e.g.*, pruning, fertilization strategies, growth regulators) that maximize yield and quality *within* a given orchard system.

Rootstock significantly affected fruit quality, yield, tree vigor, and yield efficiency (Table 1). In general, trees on Mazzard were larger and yielded fewer, higher quality fruit compared to Gisela 6 and 5. Trees on Gisela 6 yielded significantly more fruit of slightly better quality than trees on Gisela 5. Clearly the implementation of 'standard' management practices in 'Bing'/Gisela 5/6 trees leads to high yields of poor quality fruit. Less than 30 and 20% of harvested fruit were 11-row or larger for Gisela 6 and 5, respectively. In contrast, over two-thirds of fruit from Mazzard trees were in this size category. Clearly, Gisela-specific management techniques/approaches that balance crop load with vegetative vigor need to be developed.

Information transfer will continue to occur rapidly through research results reported at industry/extension meetings (e.g. Cherry Institute, Oregon Hort Society, IDFTA), on-site grower evaluations of IAREC research plots, local grower meetings, and publication of results and recommendations in industry (e.g. Good Fruit Grower) and scientific (e.g. HortTechnology, Scientia Horticulturae) periodicals.

Publications:

Lang, G.A. 1998. High density orchards and intensive crop regulation. *Good Fruit Grower* 49(16):45-47.

Lang, G.A. and D.R. Ophardt. 2000. Intensive crop regulation strategies in sweet cherries. *Acta Horticulturae* 514: 227-234.

Training system	***Rootstock***	***Fruit weight (g)***	***Tree yield (kg)***	***% ≤ 12-row***	***% ≥ 11-row***	***TCSA (cm^2)***	***Yield efficiency (kg/cm^2)***
Central leader		***6.4a***	***24.3b***	***62a***	***38a***	***155b***	***0.170a***
Spanish bush		***6.5a***	***27.8ab***	***57a***	***43a***	***185a***	***0.171a***
Palmette		***6.6a***	***25.5b***	***57a***	***43a***	***161b***	***0.174a***
Y-Trellis		***6.5a***	***31.0a***	***66a***	***34a***	***183a***	***0.196a***
	Gisela 5	***5.9b***	***29.2b***	***77a***	***23b***	***122c***	***0.244a***
	Gisela 6	***6.2b***	***38.2a***	***70a***	***30b***	***177b***	***0.220a***
	Mazzard	***7.4***	***14.0c***	***33b***	***67a***	***215a***	***0.069b***

Table 1. ***Effects of training system and rootstock on fruit yield, quality and trunk cross-sectional area (TCSA) in 7-year-old 'Bing' sweet cherry trees. Means followed by the same letter within columns are nonsignificant by LSD at P ≤ 0.05.***

Budget:
Intensive Sweet Cherry Orchard Management
Matthew Whiting
Project duration: 2001-2003
Current year: 2002
*Current year request: $19,180**

Year	2001	2002	2003
Total	$10,500	**$19,180**	$17,974

Current year breakdown

Item			
Salaries[1]		**5,797**	6,261
Benefits (28%)		**1,623**	1,753
Wages[2]	6,000	**6,000**	6,000
Benefits (16%)	960	**960**	960
Equipment[3]		**1,800**	
Supplies[4]	3,000	**2,500**	2,500
Travel[5]	540	**500**	500
Miscellaneous			
Total	$10,500	**$19,180**	$17,974

[1] 1/6 annual salary for Mr. Efrain Quiroz
[2] Time slip wages for harvest, data collection, and fruit quality analyses
[3] Field-portable scale and digital refractometer
[4] Supplies for laboratory analyses
[5] Travel to plots

* The current year request is greater than originally proposed due to a need for the listed equipment. In addition, I am requesting a portion of my second technician's salary.

CONTINUING PROJECT **YEAR 2**

PROJECT NO.: CH-01-17 (13C-3355-6202)

TITLE: Clonal Rootstock Performance/Evaluations

Principal Investigators: Matthew Whiting
Organization: Irrigated Agriculture Research and Extension Center, WSU-Prosser
Address: 24106 N. Bunn Road, Prosser, WA 99350
Phone: (509) 786-9260, (509) 781-3009
E-mail: mdwhiting@wsu.edu
Co-Investigators: G.G. Grove, Assoc. Plant Path., WSU-Prosser
W.E. Howell, NRSP5/IR2 Manager, WSU-Prosser
D.R. Ophardt, Res. Tech. Supervisor, WSU-Prosser
Cooperators: D. Allan, Grandview, D. Hayden, Pasco, M. Roy, Moxee

OBJECTIVES:
Comprehensive rootstock research is necessarily a long-term project. However, various components of the objectives will be completed annually.

1. Continue evaluation of the NC-140 regional project trial ('Bing' on 17 new rootstocks) established in 1998 for horticultural and physiological evaluations and fruit quality. Projected trial duration is 10 years.

2. Continue evaluating the 1987 NC-140 regional project trial ('Bing' on 18 rootstocks) for differences and problems in mature tree cropping and fruit quality, and long-term responses to common virus strains. Remaining trial duration is 2-3 years; approximately 15% of trees have already been removed.

3. Continue evaluating vigor and cropping performance of other orchard trials with key PNW cultivars on various rootstocks: e.g., 'Bing' on 5-6 different Gisela rootstocks in grower trials representing diverse production locations (planted in 1994-95); 'Chelan', 'Tieton', 'Cashmere', 'Liberty Bell', and 'Columbia' on Mazzard, Mahaleb, 'Colt', 'Edabriz', and various Gisela and Weiroot rootstocks (planted in 1998).

4. Analyze the physiology of interactive rootstock/scion horticultural traits (e.g., canopy leaf area, yield efficiency, precocity, graft compatibility). On-going as personnel allows.

SIGNIFICANT FINDINGS:
1987 and 1998 NC-140 Trial Rootstocks Six trees of Gisela 8 (Gi 148/9) were inoculated with prune dwarf virus and Prunus necrotic ringspot virus by Bill Howell, WSU-Prosser virologist, in September of 1998 at the Grandview rootstock trial of David Allan. This Gisela rootstock looked promising in the Grandview trial and 1987 NC-140 trial at WSU-Prosser, but there were only two specimens in the NC-140 trial which precluded their inoculation in 1995 with the other genotypes in that trial. By October of 1999, a sensitive reaction to both viruses was apparent at the Grandview trial, as determined by premature red-bronze leaf coloration and reduced shoot growth during 1999. These trees were subsequently removed. Training and growth of the 1998 NC-140 trial trees continued. Fruit yield and fruit size for 2000 both tend to strongly favor the Gisela rootstocks with fruit yield differences being much greater than those for fruit size.

In addition, from the 1998 NC-140 rootstock trial in 2001:
the following are dwarfing rootstocks (i.e., exhibit vigor reduction of 40 – 50% compared to Mazzard): W53, W72, W154, W158 Edabriz, Gi209/1, and Gi473/10 (Fig. 1)

- yield was greatest in W72, W53, Gi209/1, and Gi473/10 (12 – 15 kg/tree), intermediate in Edabriz (7 kg/tree), and lowest in W154 and W158 (2-4 kg/tree)

- the following are semi-dwarfing (i.e., 70 –80% of Mazzard): Gi195/20, Gi5, Gi7, and W13 (Fig. 2)

  - yield was greatest in Gi7 (23 kg/tree), intermediate for Gi5 and Gi195/20 (12-15 kg/tree), and lowest for W13 (2 kg/tree)

- the following are vigorous (i.e., ≥90% of Mazzard): W10, Gi6, Mahaleb, Gi318/17, and P-50 (Fig. 3)

  - yield was greatest for Gi6 (15 kg/tree), intermediate for Gi318/17 (6 kg/tree) and lowest for Mazzard, W10, Mahaleb, and P-50 (0.5 – 3 kg/tree)

- there is no clear relationship between vigor control and fruitfulness in these rootstocks
- at this early stage, no clear relationship exists between fruit yield and quality
- fruit weight was greatest on Gi318/17 (10g) and lowest on W53 (6g)

Grower Trials 'Bing' on Gisela 1, Gisela 5, Gisela 6, Gisela 7, and Gisela 11, trained to a two-leader V system at Pasco, yielded two to three times the yield on Mazzard (approx. 22 lbs/tree) in the 5th season, but fruit size was extremely small (about 6 g on the Giselas vs. 10 g on the Mazzard). Formation of double fruit was also significantly increased on all Gisela stocks, ranging from 20% (Gisela 7) to 50% (Gisela 1), compared to 17% on Mazzard. The percentage doubles on Gisela 5 was 35% and on Gisela 6 was 24%. However, at Moxee, 'Bing' on Mazzard trained to the Spanish Bush yielded about 8-9 lbs/tree with average fruit size of 9.3 g; on Gisela 5 and Gisela 6, yields were about 50-60 lbs/tree and fruit size was 9.8 to 10.1 g. Fruit soluble solids were not as high on these Gisela stocks as on Mazzard. Yields were also much higher on Gisela 1, Gisela 7, and Gisela 11, though fruit size was smaller than Mazzard with the exception of Gisela 7. These latter rootstocks are no longer recommended due to virus sensitivities. These results, along with those of the WSU-Prosser training system trial (see High Density Orchard Management project, CH-01-16), suggest that adequate fruit size and higher early yields are possible with Gisela rootstocks and depend significantly on management of the balance between cropping and vegetative vigor.

'Chelan' Rootstock Trial The 1998 'Chelan' rootstock trial continued to exhibit differential reactions between rootstocks in 2000/2001. One complete replication (4 trees) on Mahaleb were lost to gopher damage during the winter; no trees on other rootstocks were damaged. Although growth was generally excellent on all rootstocks, the trees on Mahaleb died. About 6% of the trees on Mazzard exhibit a health problem and only 2% of the trees on Colt. None of the trees on Edabriz, Gisela 6, GI 209/1, or GI 195/20 yet exhibit any unusual symptoms. All of the trees on Gisela 5 exhibit a minor degree of premature leaf coloration and/or premature defoliation. These results with Mahaleb confirm several grower observations of tree mortality on Mahaleb. Trees exhibiting incompatibility may provide source materials for exploring the possibility of developing a biochemical test for graft incompatibility in cherry.

'Lapins' Rootstock Trial The 1998 'Lapins' rootstock trial also began to exhibit the first potential rootstock incompatibility reaction in 1999. All trees on Mazzard are healthy thus far, but 25% of the trees on Mahaleb exhibit some degree of red-bronze leaves in the fall after good shoot growth during the summer. These trees will be followed for further symptom expression and if graft incompatibility appears likely, such trees will provide a second set of source materials for the biochemical analysis undertaken with the Chelan trees.

METHODS:
The 1998 NC-140 plot was planted at WSU-Prosser's Roza Experimental Unit, with 'Bing' as the scion cultivar and 'Van' as the pollinizer, on the German rootstock series Gisela 4 (GI 473/10), Gisela 5 (GI 148/2), Gisela 6 (GI 148/1), Gisela 7 (GI 148/8), GI 195/20, GI 209/1, and GI 318/17; the German rootstock series Weiroot 10, W13, W53, W72, W154, and W158; Edabriz (France); P-50 (Japan); and Mazzard and Mahaleb seedlings as controls. There are 8 replications/rootstock, with guard tree around the plot perimeter, and tree spacing of 19.5 x 19.5 ft (6.0 x 6.0 m) to reduce the potential influence of neighboring trees. Irrigation by microsprinklers and frost protection by wind machine were installed. A duplicate plot was planted for potentially destructive analyses, such as physiological stress treatments. Improved estimates of rootstock influence on canopy vegetation (a key measure of potential fruit sizing capability) will be made with a non-destructive, portable, microprocessor-based leaf area meter to be obtained in 2002.

A new plot of 'Chelan' on Mazzard, Mahaleb, 'Colt', 'Edabriz", and various Gisela rootstocks was planted in 1998 to document whether industry concerns of certain graft incompatibilities with this important new variety are warranted. A small plot of 'Lapins' on Mazzard and Mahaleb was also planted to examine graft incompatibility potential. If and when evidence of incompatibilities arise, tissue samples will be taken from respective graft unions for biochemical analysis and investigation of the potential for developing a screening test for other incompatible rootstock/scion combinations.

Finally, 'Bing' on the more promising rootstocks from the 1987 NC-140 trial will continue to be evaluated physiologically for scion dormancy, winter flower bud cold hardiness, and spring frost susceptibility, as personnel permit.

RESULTS & DISCUSSION:
This project generates critical clonal rootstock/scion performance information that is providing new strategies for early-producing, high-yielding, efficiently-harvested PNW sweet cherry orchards. The screening for incompatibilities may help prevent economic losses due to unforeseen graft incompatibility of new rootstocks, and screening for adaptability to environmental extremes may help prevent catastrophic economic losses in new or mature orchards. The analysis of rootstock influence on important horticultural characteristics assists in developing management strategies for maintaining productivity in high-density orchards (see Figs. 1-3). In addition to annual NC-140 project reports on vigor and yield, 5-year cumulative studies will be compiled after 5 and 10 years in the 1998 trial. Information transfer will occur through research reports at industry meetings (e.g., Cherry Institute, IDFTA), on-site grower evaluations of IAREC and industry cooperator research plots, and publication of results and recommendations in industry (e.g., Good Fruit Grower) and scientific periodicals (e.g., Fruit Varieties Journal, HortScience, etc.).

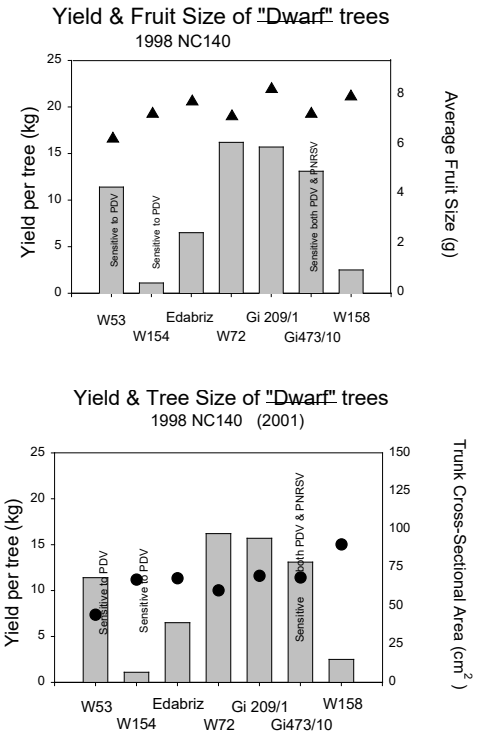


Figure 1. Yield, tree vigor (trunk cross-sectional area), fruit size, and virus sensitivity of dwarfing (40 – 50% of Mazzard) rootstocks from the 1998 NC-140 planting.

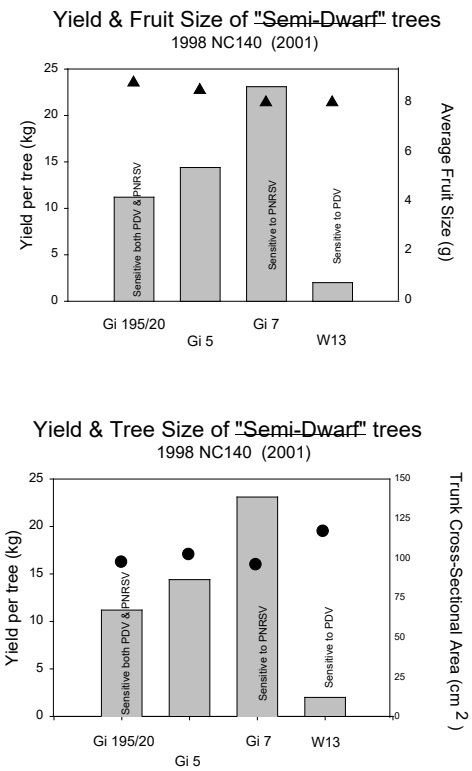
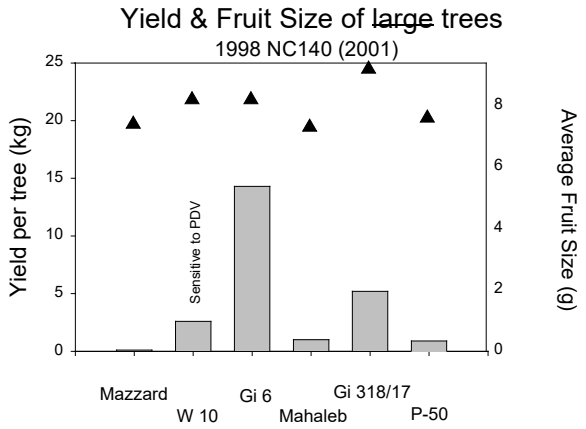
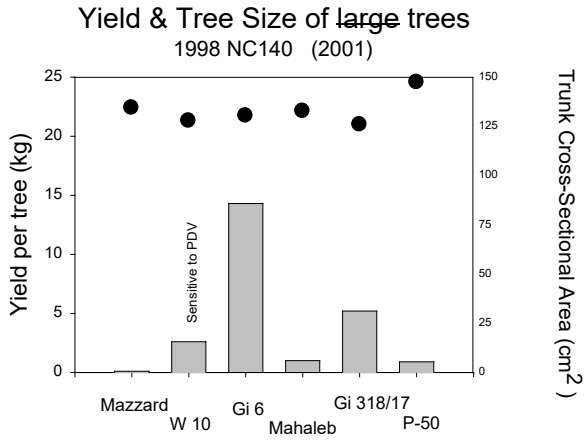


Figure 2. Yield, tree vigor (trunk cross-sectional area), fruit size, and virus sensitivity of semi-dwarf (70-80% of Mazzard) rootstocks from the 1998 NC-140 planting.

Figure 3. Yield, tree vigor (trunk cross-sectional area), fruit size, and virus sensitivity of vigorous (≥90% of Mazzard) rootstocks from the 1998 NC-140 planting.





Budget:
Clonal Rootstock Performance/Evaluations
Matthew Whiting

*Current year request: $19,380**

Year	2001	2002	2003
Total	$15,580	**$19,380**	$17,974

Current year breakdown

Item			
Salaries[1]	5,897	**5,797**	6,261
Benefits (28%)	2,123	**1,623**	1,753
Wages[2]	3,500	**6,000**	6,000
Benefits (16%)	560	**960**	960
Equipment[3]		**2,000**	
Supplies[4]	3,000	**2,500**	2,500
Travel[5]	500	**500**	500
Miscellaneous			
Total	$15,580	**$19,380**	$17,974

[1] 1/6 annual salary for Mr. Efrain Quiroz
[2] Time slip wages for harvest, data collection, and fruit quality and laboratory analyses
[3] Datalogging equipment – Campbell Scientific CR10x and environmental sensors
[4] Supplies for laboratory analyses and orchard maintenance
[5] Travel to plots

*The current year's request is greater than originally budgeted. I am requesting datalogging equipment to monitor tree performance with sensors (*e.g.*, stem dendrometer) and orchard microclimate. In addition, I am requesting a portion of my second technician's salary.

CONTINUING PROJECT **YEAR 3**

WTFRC Project #CH-01-05 Agricultural Research Foundation #3740

Project Title: Propagation and production of tree fruits and nuts

PI: William M. Proebsting
Department of Horticulture
Oregon State University
Corvallis, OR 97331

Cooperators: Anita Azarenko
Department of Horticulture
Oregon State University

Matt Whiting
Washington State University-Prosser

Objectives: This project conducts research in propagation of cherry, pear and hazelnut to: 1) help the flow of new germplasm through research towards commercial propagation, 2) improve propagation of these species, 3) maintain several dozen clones in the field and in tissue culture and 4) study shoot regeneration and genetic transformation of cherry rootstocks.

Significant Findings:

- Double-phase tissue culture improves micropropagation of cherry shoots. The key component of the liquid phase is BAP (benzylaminopurine).
- The double-phase technique has been adapted by commercial micropropagators. A nursery established a micropropagation lab with our consultation and supplies a large proportion of the tissue cultured cherry liners.
- Annual provision of liners of 148-1 to GRC. Liners of PiKu 1.10, 4.20, 4.22 and Bz-3-II will be sent to GRC January, 2002. By having over 20 cherry rootstocks in tissue culture, we are able to provide material to other research programs.
- We have developed a regeneration system for cherry that has increased from one to eight the number of rootstock clones that can be regenerated.

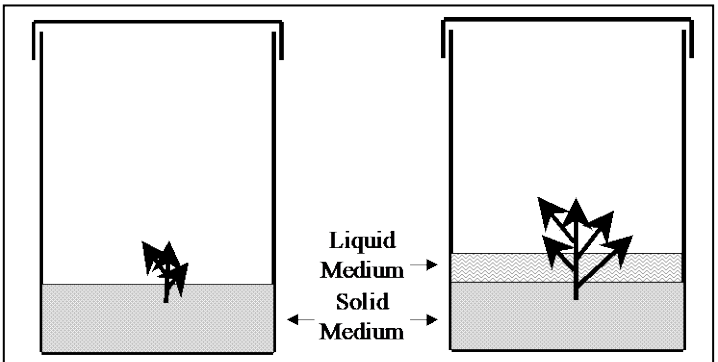


Figure 1. Single-phase vs. double-phase tissue culture.

Methods:

Micropropagation. Cherry clones were established in sterile conditions by surface sterilizing actively growing shoots in 10% bleach solution and planting the shoots on MS medium consisting of 0.8% agar, 3% sucrose plus MS salts and vitamins. Shoots which were sterile and still actively growing were transferred to a multiplication medium consisting of DKW medium plus 1 ppm benzylaminopurine (BAP). Every 4-6 weeks, shoot clumps were divided into single shoots and re-cultured on multiplication medium.

When liquid medium is used in double-phase culture, enough liquid is added, about 25 ml, to nearly cover shoots that had just been divided and transferred.

When a sufficient number of shoots are available, the surplus is treated with indolebutyric acid (IBA) to stimulate rooting. Rooted shoots are transplanted into clean potting medium, grown under intermittent mist for two weeks and then transferred to the greenhouse. In the greenhouse, the shoots are grown to liner size and transferred to other research programs.

For transfer to commercial micropropagators, shoot cultures are sealed in sterile, plastic pouches containing a small amount of DKW solid medium and mailed to the nursery.

Regeneration. Expanded leaves from tissue cultured shoots are wounded by several cuts across the midrib and placed on Regeneration Medium 1 (RM1) in the dark for 48 hours, followed by three weeks under light. Leaves are then transferred to Regeneration Medium 2 (RM2). As shoots develop on the leaves, they are transferred to DKW medium plus 1 ppm BAP and micropropagated as above.

Transformation. Agrobacterium strains carrying genes for antibiotic or herbicide selection and GUS reporter genes are used to inoculate cherry leaflets at the time they are cut and placed on RM1. After three days, the shoots are washed and placed on fresh RM1 containing antibiotic (timentin, 400 mg/l) which kills the bacteria. Leaves are then transferred to RM2 containing antibiotic (kanamycin) or herbicide (bialaphos), which kills untransformed plant cells. We then try to stimulate shoot development from the remaining transformed cells.

Results and Discussion:

Micropropagation. The PiKu clones initially grew very slowly in tissue culture. Double-phase culture dramatically improved multiplication of most of the PiKu clones and is proving to be an extremely valuable technique for propagating difficult clones (Table I). Double-phase prevented these clones from dying out. Even using double-phase, most of these clones still multiply slowly and we continue to test new treatments to improve growth.

Table 1. Comparison of single- and double-phase media on multiplication of cherry rootstocks.

Clone	Single-phase	Double-Phase
PiKu 1.10	1-1.4	10.8
PiKu 4.11	0.9	2.6
PiKu 4.13	Re-initiated, June, 2001	
PiKu 4.17	1.0	2.5
PiKu 4.20	0.9	4.5
PiKu 4.22	1-1.5	7.1
Bz-3-II	0.5-0.9	3.1

A drawback of double-phase is that the liquid phase spreads contamination within the culture flask. An ongoing problem with tissue culture of woody plants is bacteria that grow in the plant tissue. It is difficult to remove these. Some of them spread quickly in double-phase and destroy cultures. Others are slow growing and cause fewer problems. Dealing with these contaminants requires caution and slows propagation of some clones.

We have done a series of experiments with double-phase culture in an effort to determine the components that make it work. For cherry, shoot growth responded to BAP content of the liquid phase and to transfer to fresh medium (Table 2). The other treatment that increases growth is to transfer uncut shoots to fresh medium. As a result, we assume that BAP is the factor supplied by the fresh medium that stimulates growth. Adding BAP solution to cultures is far more efficient than making fresh medium and transferring the cultures.

Table 2. Effect of liquid phase composition on shoot growth of Bz-3-II.

Treatment		Multiplication
Single-Phase		
	Untransferred	4.5
	Transferred intact to fresh medium	5.7
Double-Phase		
	Water	3.9
	Hormone-free	4.1
BAP	1 ppm	6.4
	2.5	7.8
	5	8.3
IBA	0.01 ppm	4.4
	0.1	4.6
	1	4.1
GA_3	0.01 ppm	4.5
	0.1	4.3
	1	4.5

Another experiment was done to study the interaction of BAP in the solid and liquid phases. BAP at 0.5 ppm in both phases provided the most consistent response.

Using these micropropagation techniques, as well as methods for propagating softwood cuttings that have been described in previous reports, we help the flow of new rootstocks through the research system and into commercial propagation. The major focus is to feed liners to the Germplasm Research Consortium (GRC). About 200 Gi6 are provided annually for scion testing. We also provide material for other research programs. Two hundred plus liners of clones 1.10, 4.22 and Bz-3-II will be sent to Prosser January, 2002. About 100 liners of 4.20 are ready, whereas 4.11 and 4.17 have been slower to respond. Clone 4.13 had to be re-initiated in spring, 2001.

Anita Azarenko is particularly interested in Gi 196-4 for the Willamette Valley. We are able to provide liners for her studies. Anita also recently completed a large evaluation of pseudomonas resistance in cherry genotypes. Most of the genotypes that Anita needed were provided by our program and Luigi Meneghelli, the technician supported by this program, provided a great deal of technical assistance to Meg Roche who did the study. Several of the Giessen clones are hypersensitive to prunus necrotic ringspot virus. We provide liners of some of these clones for Bill Howell's work at Prosser. Jack Pinkerton, a USDA scientist at Corvallis, uses cherry liners for nematode studies.

Mature cherry scion varieties are difficult to micropropagate. For several years, Greg Lang has been interested in obtaining self-rooted cherry varieties for his studies. We have been attempting to establish several varieties in tissue culture to help Greg and this has proved to be a hard problem that we learn from. We currently have several varieties in culture, but only 'Rainier' multiplies above replacement levels.

These mature clones have particularly tough internal contamination. This has made us cautious about using double-phase to improve growth. However, in small trials with 'Rainier,' the cleanest variety, double-phase with 1 ppm BAP improved leaf growth and shoot elongation, but did not increase axillary budbreak. We plan to test higher BAP concentrations for their effects on shoot elongation. Longer shoots with more nodes would result in shoot multiplication.

Regeneration. Cherries have been a very difficult species to regenerate. Our goal has been to carefully and systematically develop a reliable regeneration system that other programs can use. Initially, only Gi154-7 regenerated shoots in the system we started with. Over several years, we have methodically

devised a two-step system to first initiate shoot meristems and then stimulate their growth. Over the past year, we have determined that eight cherry clones regenerate significant numbers of shoots in this system, a substantial improvement compared to where we started.

Transformation. We use *Agrobacterium tumefaciens* to transfer genes into plant cells. Initially, we are attempting to transfer reporter (GUS) and selection (bar or Npt) genes. Reporter genes "report" their presence in plant cells indicating whether transformation has occurred. Selection genes confer herbicide or antibiotic resistance, which permits growth of transformed cells on antibiotic medium, but kills or prevents growth of untransformed cells. Antibiotics are also used to suppress agrobacterium once transformation has occurred.

We find that cherry tissues show transformation initially, but we fail to obtain shoots expressing the reporter gene. One possibility is that the shoots that develop are not transformed. Another possibility is that the cells are transformed, but that the transferred genes (transgenes) have been silenced.

Silencing of transgenes is an important problem in biotechnology. In many cases, it appears that plants can recognize transgenes as foreign and silence them by methylating them. Methylation can also be stimulated by the antibiotics used to select resistant cells (2).

The chemical 5-azacytidine (5-AC) is used to reduce methylation, which activates gene expression, at least temporarily (1,3). One study found that grafting transformed tobacco tissue containing silenced genes to a seedling rootstock activated the transgenes (3).

Our goal is to use 5-AC to aid development of transformed cherry clones. 5-AC could be useful in a number of ways, 1) it can activate agrobacterium cultures used to treat plant tissues and 2) it can re-activate transgenes in plant tissues. Even if reactivation is temporary, 5-AC-induced activation would aid selection of transformed shoots. Subsequently, grafting may result in longer term activation. These problems indicate some of the complexity of genetic transformation.

References.

1. Palmgren et al. 1993. Treatment of *Agrobacterium* or leaf disks with 5-azacytidine increases transgene expression in tobacco. Plant Molecular Biology 21:429-435.
2. Schmitt et al. 1997. Antibiotics induce genome-wide hypermethylation in cultured *Nicotiana tabacum* plants. Journal Biological Chemistry 272:1534-1540.
3. Van Slogteren et al. 1984. Silent T-DNA genes in plant lines transformed by *Agrobacterium tumefaciens* are activated by grafting and by 5-azacytidine treatment. Plant Molecular Biology 3:333-336

Budget:
Propagation and production of tree fruits and nuts
William M. Proebsting
Project Duration: Long term
Current Year: 2002

Details for Cherry Request:

	2002 (proposed)
FRA	**6,780**
OPE (50%)	**3,390**
Student Wages	**950**
OPE (5%)	**48**
Supplies	**713**
Travel	**119**
Total	**12,000**

Details of overall program budget:

Year	2000-01 (past)	2001-02 (current)	2002-03 (proposed)
Total	49,978	50,903	50,497[1]
Cherry Request	12,000	12,000	12,000

Details

	2000-01	2001-02	2002-03
Salary, Faculty Research Assistant[2]	26,636	27,972	28,531
OPE	14,117 (53%)	13,706 (49%)	14,266 (50%)
Student Wages[3]	4,500	4,500	4,000
OPE	360 (8%)	360 (8%)	200 (5%)
Services and Supplies	4,000	4,000	3,000
Travel[4]	500	500	500
Total	49,753	50,903	50,497[1]

[1] This is the total amount requested to support the entire program, which includes filberts, cherries and pears.
[2]Luigi Meneghelli, Research Assistant
[3]Undergraduates maintain most of the cultures and field plots
[4]Travel to our plots at the Lewis-Brown Farm

CONTINUING PROJECT **YEAR 2**

WTFRC Project # CH0120 (Modified) **WSU Project #3298**

Project Title: Bioregulator Uses for Vigor Management, Stimulating Cropping and Facilitating Mechanical Harvesting in Sweet Cherry

PI: Don C. Elfving, Horticulturist
Organization: WSU Tree Fruit Research and Extension Center, Wenatchee, WA
Address: 1100 N. Western Ave., Wenatchee, WA 98801
Phone: 509-663-8181 ext. 252
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Cooperators: Steven R. Drake, Horticulturist, USDA/ARS, TFRL, Wenatchee, WA
James R. McFerson, Horticulturist and Manager, WA Tree Fruit Research Commission, Wenatchee, WA
Tom Auvil, Horticulturist, WA Tree Fruit Research Commission, Wenatchee, WA
Matthew D. Whiting, Assistant Horticulturist, WSU-IAREC, Prosser, WA
Tory Schmidt, Agricultural Technician, WA Tree Fruit Research Commission, Wenatchee, WA
Dwayne B. Visser, Agricultural Research Technologist II, WSU-TFREC, Wenatchee, WA

Objectives (General):

1. Evaluate the potential of Apogee®(BASF Corp.) and Ethrel®(Aventis CropScience) for control of vegetative vigor and stimulation of flowering and early fruiting in young, vigorous sweet cherry trees on seedling rootstocks in standard and high-density plantings.
2. Develop specific recommendations for the use of these products, separately or together, to accomplish the dual goals of growth control and stimulation of cropping in important sweet cherry cultivars.
3. (**NEW**) Develop improved recommendations for the use of Ethrel for loosening sweet cherries for mechanical harvest while preserving fruit quality.
4. (**NEW**) Evaluate effects of ReTain and Ethrel for loosening and maintenance of fruit quality.
5. (**NEW**) If any new products become available, initiate tests for efficacy in loosening sweet cherries while examining effects on fruit quality.

Objectives (Ongoing. Schedule of activities 2002-2003):

1. Continue to evaluate effects of Apogee and Ethrel for control of vegetative growth in sweet cherry cultivars such as 'Bing', 'Lapins', 'Tieton', 'Rainier', and others as appropriate, when grown on seedling rootstocks.

2. Assess the effects of Apogee and Ethrel separately and combined on vegetative behavior of vigorous sweet cherry trees under a variety of environmental conditions in north-central and south-central WA.

3. Determine the effects of these products, when applied separately and together, on flowering and fruiting of previously non-cropping trees. Determine where in the tree flowering sites are being stimulated, the amount of increase in flowering, if any, and the resultant effects on fruit set, fruit yield and fruit size.

4. Examine treated trees in subsequent years to determine whether a single season's treatment program confers an ongoing change in reproductive behavior.

5. Evaluate Apogee and Ethrel effects on cherry fruit size, color, firmness, solids content and quality. Determine the potential for use of Apogee and Ethrel in management of growth and cropping in fruiting cherry trees.

Objectives (New, Schedule of activities 2002-2003):

1. Determine the optimum Ethrel concentration for suitable reduction in fruit removal force and acceptable postharvest fruit quality under mechanical harvesting conditions.

2. Examine the effect of time of Ethrel application in relation to fruit maturity on fruit removal force and fruit quality.

3. Assess the effect of ReTain on sweet cherry fruit removal force and fruit quality. Combine ReTain and Ethrel programs to determine if fruit loosening can be stimulated with Ethrel while retarding fruit quality losses with ReTain.

Significant findings (ongoing):

- Vegetative growth can be controlled by Apogee and Ethrel; best control appears to result when the two products are combined and applied more than once.
- Apogee+Ethrel tank mixes stimulate a late-season growth flush but appear better for increasing flowering.
- Flowering and yield increased when Apogee and Ethrel were tank mixed and applied twice with a three-week interval between applications. Single applications of either Apogee, Ethrel or the tank mix had little or no beneficial effect on flowering.
- Vegetative growth responses to Apogee and/or Ethrel have been observed in four cultivars ('Attika', 'Bing', 'Lapins', 'Regina'). Cultivars differ significantly in their growth responses to Apogee and Ethrel. Do they also differ in flowering and fruiting responses?

Significant findings (new):

- Ethrel-based loosening of sweet cherries is rate dependent; the optimum Ethrel rate for loosening under WA conditions remains to be determined.
- The effectiveness of Ethrel for loosening sweet cherries does not appear to be related to whether the application is made with a high volume of water (200 gallons/acre airblast) or a lower volume (50 gallons/acre Proptec). Proper calibration of the sprayer is likely more important.
- Ethrel solution pH does not appear to affect fruit loosening when the solution is applied shortly after mixing.
- Drying conditions at the time of spray application may not be an important determinant of successful loosening of sweet cherries with Ethrel.
- In a preliminary trial, ReTain appeared to reduce fruit removal force to a small extent but had no effect on any other fruit quality parameters at harvest.

Methods (both components of project):

Trials will be carried out in suitable commercial and experimental cherry orchards in Washington where vegetative vigor and lack of fruitfulness are problems or where mechanical harvest can be conducted. Cultivars to be tested include, but may not be limited to, 'Bing', 'Lapins', 'Tieton', and 'Rainier'. The final number and location of trials depend on the availability of grower-cooperators and funding. Collaborative projects will be established in cooperation with interested colleagues in other research/extension units. Applications will be carried out with commercial or experimental

airblast equipment or with hand applications, as appropriate. Single- or multiple-tree plots will be chosen as appropriate, and treatments will be arranged in randomized complete-block designs to permit appropriate statistical analyses of data.

The information developed from these studies will be communicated to Washington sweet cherry growers via industry meetings, meetings of scientific associations, in journal and industry trade publications, through presentations at the Washington State Horticultural Association annual meeting and other grower meetings, at field days and grower tours, through colleagues in Cooperative Extension, and through articles published in the *Good Fruit Grower* and other trade and scientific journals.

Budget:
Bioregulator Uses for Vigor Management, Stimulating Cropping and Facilitating Mechanical Harvesting in Sweet Cherry
Don C. Elfving
Project duration: three years
Current year: 2002
Original budget request: $

Year	Year 1 (2001)	Year 2 (2002)	Year 3 (2003)
Total	7,500	**16,740**	17,960

Current year breakdown

Item	Year 1 (2001)	Year 2 (2002)	Year 3 (2003)
Salaries (Technical)[1]	3,000	**6,000**	6,500
Benefits (28%)	840	**1,680**	1,820
Wages (Time-slip)[1]	1,000	**3,500**	4,000
Benefits (16%)	160	**560**	640
Equipment[2]	0	**1,000**	0
Supplies[3]	500	**1,000**	1,500
Travel[4]	1,500	**2,500**	3,000
Miscellaneous	500	**500**	500
Total	7,500	**16,740**	17,960

Budget increase due to added objectives

[1]Technical (0.40FTE D. Visser) and time-slip help is essential to collect the volume of data needed to evaluate growth, flowering, fruiting, fruit loosening and fruit quality responses to Apogee and Ethrel.

[2]Purchase of pull-force gauge.

[3]This category includes a variety of miscellaneous supplies, non-capital equipment, consumables, etc. that are needed to carry out the research project.

[4]Treatment application and frequent data collection in distant sites, e.g. Pasco, Prosser, Yakima, Cashmere, Orondo, Quincy, etc. Includes vehicle lease-to-purchase, operating, repair costs.

CONTINUING PROJECT **YEAR 2**

Project #: CH-01-07

Project title: Effects of Thinning Methods on Sweet Cherry Fruit Size and Quality

PI: Roberto Núñez-Elisea
OSU-Mid-Columbia Agric. Research and Extension Center, Hood River, OR

Cooperators: Jim McFerson (WTFRC, Wenatchee, WA)
Dana Faubion (WSU Coop. Extension, Yakima, WA)
Zhiguo Ju (USDA-ARS Tree Fruit Research Laboratory, Wenatchee, WA)

Research Assistants: Helen Cahn (OSU-MCAREC)
Tory Schmidt (WTFRC, WA)
Frances Ceya and Kevin Spiegel (WSU)

Objectives:
The goal of this study is to develop effective manual and/or chemical methods of crop load reduction in sweet cherry trees to increase production of large, high-quality fruit. The efficacy of thinning floral buds or young fruit by hand, as well as of chemical bloom-thinning compounds is being assessed.

Significant findings for 2001:

- In The Dalles, hand thinning of floral buds or young fruit, or vegetable oil emulsion (VOE) spray treatments, did not produce larger or firmer fruit in vigorous, 6-yr-old 'Lapins'/Mazzard trees. Overall, fruit were larger (about 12 g) at this site than at Wenatchee or Yakima, with 60-80% of fruit in the 9-row and larger size category.

- 'Lapins'/Gisela 11 trees at Wenatchee produced significantly larger fruit when sprayed with a mixed solution of VOE, lime sulfur, and/or ATS, but not when VOE was sprayed alone. Overall, fruit were smaller at Wenatchee than at The Dalles, as only 20-50% of the crop fell in the 9-row and larger size category. All thinning treatments increased fruit firmness at this site.

- At Yakima, hand fruit thinning and a 2.5% Armothin spray significantly increased fruit weight in 'Lapins'/Mazzard trees. Average fruit weight of controls was 7.7 g, whereas for the hand fruit thinning and 2.5 % Armothin treatments it was 9.4 g and 9.2 g, respectively.

Methods
Thinning trials were conducted during 2001 in three grower cooperators' orchards located in The Dalles, Oregon, and Wenatchee and Yakima, Washington. Sweet cherry trees of the self-fertile cultivar 'Lapins' on different rootstocks were used for the study. Characteristics of trees at each experimental site are shown in Table 1. Hand thinning of floral buds or developing fruitlets was performed at each site, as well as sprays of three chemical bloom-thinning agents: a vegetable (corn) oil emulsion (VOE; 50% a.i.), lime sulfur (LS), or ammonium thiosulfate (ATS). The chemicals were applied alone or in different combinations as shown in Table 2. VOE sprays obstruct flower opening, causing abscission of non-fertilized flowers, whereas ATS and lime sulfur act by caustic desiccation of floral parts in open flowers.

Table 1. Experimental sites for 'Lapins' sweet cherry thinning trials, 2001.

Site	Rootstock	Tree age in 2001	Training system	Harvest date	Trees per treatment
The Dalles, OR	Mazzard	6th leaf	Steep leader	7/25	7; control = 5
Wenatchee, WA	Gisela 11	7th leaf	Steep leader	7/19	5
Yakima, WA	Mazzard	5th leaf	Spanish bush	7/13	5

Table 2. Thinning treatment description at each experimental site, 2001.

Treatment	Chemical rates and application dates		
	The Dalles, OR	Wenatchee, WA	Yakima, WA
Control	Non-treated	Non-treated	Non-treated
50% hand bloom thinning	Floral buds, 4/4	Indiv. flowers, 4/27	Indiv. flowers, 5/6
50% hand fruit thinning	5/11	5/18	5/16
VOE applied once (1x)	(3% a.i.) 4/12	(4% a.i,) 4/27	(3% a.i.) 4/16
VOE applied twice (2x)	(3% a.i.) 4/7, 4/16	(4% a.i,) 4/27, 5/1	(3% a.i.) 4/16, 4/20
(VOE + LS) (1x)	--	(4% a.i, 2%) 4/27	--
(VOE + LS) (2x)	--	(4% a.i., 2%) 4/27, 5/1	--
(VOE + LS) + (ATS)	--	(4% a.i., 1%) 4/27, 5/1	--
Armothin	--	--	(2.5%) 4/16
Thinrite	--	--	(1.5 pt/100 gal) 4/16

The Dalles

Treatments consisted of floral bud removal or fruitlet removal by hand, 3% VOE (50% a.i; 6 gal VOE/100 gal water = 3% VOE solution) applied once (at approximately 20% full bloom) or twice (at approximately 20% full bloom, and at approximately 80% full bloom) to whole trees (Table 2). Approximately 50% of initial floral buds or fruitlets were removed. Fruitlets were removed when they measured approximately 1cm in length. Hand thinning of floral buds was done on two branches per tree. Fruit thinning was done on one branch per tree.

VOE was applied with a hand-gun sprayer to run-off. The VOE product used in this trial was prepared and kindly donated by Dr. Zhiguo Ju. Measurements included flower and fruit counts, fruit firmness and diameter (using a FirmTech2 firmness instrument), and total yield for control and VOE-sprayed trees. Control trees were not treated. Fruit samples were collected July 20, and trees were harvested on July 25.

Wenatchee
Treatments tested in The Dalles were also applied at this site, with the variation that 4% VOE was used instead of 3% VOE (Table 2). In addition, three bloom-thinning combination sprays were tested: VOE + 2% lime sulfur applied once or twice, and VOE + 2% lime sulfur followed by 1% a.i. ATS (1.7 gal/l). Fruit samples obtained at harvest were used to determine firmness and diameter with a FirmTech firmness instrument.

Yakima
In addition to the five treatments tested in The Dalles and Wenatchee, the chemical bloom-thinners Armothin (a non-ionic surfactant) at 2.5% vol:vol and Thinrite (endothall) at 1.5 pt/100 gal, were used at Yakima (Table 2). VOE was applied at first bloom and at 85% full bloom. Measurements included branch diameter, and the number and weight of fruit harvested per branch.

Results and discussion:
The Dalles
Hand thinning of floral buds or young fruit, or VOE spray treatments, did not increase average fruit weight in 'Lapins'/Mazzard trees (data not shown). All treatments produced large fruit (average about 12 g) at this site, with about 90% of the number of fruit tested being 9.5-row or larger, and about 60% to 80% of fruit being size 9-row or larger (Figure 1). Branch fruit set (fruit harvested/number of initial flowers) for the double VOE spray was significantly lower than the control or single VOE-sprayed trees (39 % vs. 75%; data not shown).

Tree total yield was recorded for control and VOE-sprayed trees (Table 3). Fruit samples for all treatments were collected five days before commercial harvest, a day on which rain occurred. Fruit firmness decreased for fruit samples collected on the day of commercial harvest (Table 3), possibly due to exposure to rain five days earlier, greater maturity of fruit, or a combination of both factors.

Based on samples collected pre-harvest (July 20), there were no significant differences among treatments in average fruit weight, which ranged from 11.4 g to 12.3 g, or in fruit firmness, which ranged from 343 to 372 g/mm (data not shown). The number of fruit harvested from each experimental branch was not significantly different among treatments, ranging from 80 to 150 (data not shown).

Larger fruit was not obtained in 'Lapins'/Mazzard trees in The Dalles either by hand thinning of floral buds or fruitlets, or by a single or double spray of 3% VOE. Mazzard is a vigorous rootstock that does not stimulate fruit over-set. It is possible that at this site, tree initial crop loads were non-limiting and further crop load reduction did not stimulate fruit enlargement.

Table 3. Yield and comparison of fruit firmness for fruit samples of 'Lapins'/Mazzard trees in the Dalles. Fruit samples were collected July 20, and rain occurred on this day. Commercial harvest was on July 25.

Treatment	Yield		Fruit firmness (g/mm)	
	lbs/tree	tons/acre	Pre-harvest (July 20)	Harvest (July 25)
Control	116.5	6.34	355.89	277.98
VOE 3% (1x)	96.4	5.25	337.98	294.78
VOE 3% (2x)	60.5	3.29	343.01	280.70
Significance ($P < 0.05$)	*ns*	*ns*	*ns*	*ns*

Wenatchee
'Lapins'/Gisela 11 trees at Wenatchee produced significantly larger fruit when sprayed with a mixed solution of 4% VOE and 2% lime sulfur, or when sprayed with a mixture of 4% VOE and 2% lime sulfur, followed by a spray of ATS, but not when VOE was sprayed alone (Table 4). The number of fruit harvested per branch in all treatments was significantly lower than in controls except for the VOE single spray (range 23 to 143; data not shown). All thinning treatments increased fruit firmness in relation to the controls (Table 4), and there was a significant increase in °Brix and total acids for fruit from the double VOE-lime sulfur spray and VOE-lime sulfur followed by ATS (data not shown).

Table 4. Fruit set and size in 'Lapins'/Gisela 11 trees at Wenatchee, WA, 2001.

Treatment	Fruit set at harvest	Harvested fruit/cm^2 branch CSA	Fruit size (mm diam.)	Row size equivalent	Fruit firmness (g/mm)
Control	75.1 a	26.3 a	27.62 c	10	318.5 c
VOE (1x)	51.3 b	18.1 a	27.56 c	10	355.9 b
VOE (2x)	34.3 bcd	15.9 b	27.82 bc	9.5	398.8 a
(VOE + LS) + (ATS)	13.4 e	5.4 c	29.41 a	9	402.1 a
VOE + LS (1x)	30.4 cde	8.5 bc	28.27 b	9.5	398.9 a
VOE + LS (2x)	17.6 de	5.31 c	29.06 a	9	410.8 a
Hand bloom thinning	49.1 b	18.8 a	27.39 c	10	352.9 b
Hand fruit thinning	43.7 bc	14.2 bc	27.65 c	10	351.4 b

Mean separation by SAS LSMeans ($P < 0.05$), means sharing the same letter are not significantly different

Overall, fruit from trees at Wenatchee were smaller than at The Dalles, with 9-row and larger fruit representing only about 20% to 50% of the number of fruit harvested (Figure 2). The increase in fruit size obtained in 'Lapins'/Gisela 11 trees was attributed to heavy initial crop loads. After thinning, re-distribution of reserves and current photosynthates to remaining fruit may have caused greater growth rates and an increase in fruit size.

Yakima
Armothin and hand fruit thinning produced significantly larger fruit than controls, whereas sprays of VOE alone did not (Table 5). The number of fruit harvested per hand-thinned branch (140) was significantly lower than that from the rest of treatments (range 290 to 368 fruit; data not shown).

Although VOE sprays effectively prevented flower opening in the self-fertile cultivar 'Lapins' in these initial trials, fruit size generally was not increased probably because a proportion of non-opened flowers were capable of setting fruit through self-pollination.

Table 5. Fruiting efficiency and fruit weight in 'Lapins'/Mazzard trees at Yakima, WA.

Treatment	No. of fruit harvested/ cm^2 branch CSA	g of fruit/ cm^2 branch CSA	Fruit wt.(g)
Control	86.2 a	624.4 a	7.7 c
3% VOE (1x)	62.6 ab	480.4 ab	8.0 c
3% VOE (2x)	58.8 b	462.8 ab	8.2 bc
Armothin 2.5%	47.0 b	417.2 b	9.2 a
Thinrite 1.5 pt/100 gal	54.0 b	429.3 b	8.4 abc
Hand bloom thinning	63.5 ab	498.8 ab	8.4 bc
Hand fruit thinning	18.8 c	177.4 c	9.4 a

Mean separation by SAS LSMeans ($P < 0.05$).

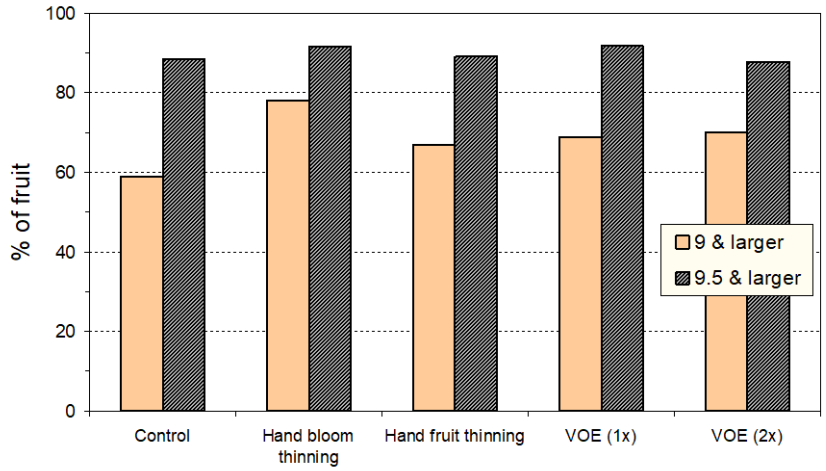

Fig. 1. Effect of manual and chemical thinning treatments on production of 9-row and larger (includes all fruit of row sizes 9, 8.5, 8, and larger), and 9.5 and larger fruit (includes all fruit of row sizes 9.5, 9, 8.5, 8, and larger) in 'Lapins'/Mazzard trees in The Dalles, OR, in 2001. Percentages are means based on sub-samples consisting of 25-50 fruit. For each fruit size category, differences among treatments were not significantly different according to SAS LSMeans procedure ($P < 0.05$).

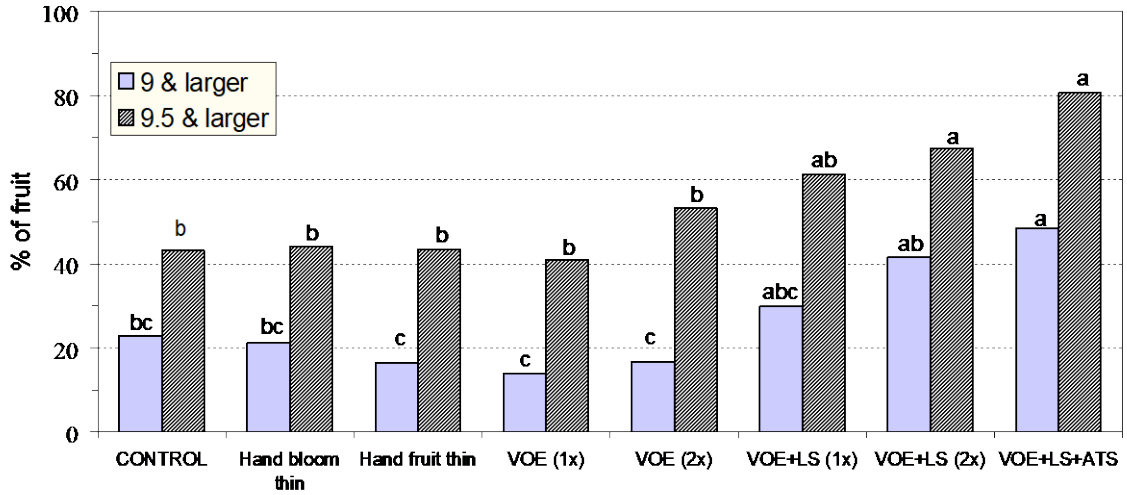

Fig. 2. Effect of manual and chemical thinning treatments on production of 9-row and larger fruit (includes all fruit of row sizes 9, 8.5, 8, and larger), and 9.5 and larger fruit (includes all fruit of row sizes 9.5, 9, 8.5, 8, and larger) in 'Lapins'/Gisela 11 trees in Wenatchee, WA, in 2001. Percentages are means based on sub-samples consisting of 40-100 fruit. Means with the same letter within each fruit size category are not significantly different according to SAS LSMeans procedure ($P < 0.05$).

A main goal for this first year was to develop appropriate experimental protocols to refine our estimations of flowering and fruiting rates, crop load reduction, fruit set, and fruit quality. During 2002 we plan to conduct experiments to test the hypothesis that fruit development can occur in non-opened (due to VOE spray) flowers through self-pollination. We also plan to compare the effects of VOE sprays on the degree of thinning and fruit set achieved in self-fertile vs. self-sterile cultivars, and the impact on fruit size and quality. This information will help clarify the potential of VOE sprays as a chemical bloom-thinner for self-fertile sweet cherries.

Budget:
Effects of Thinning Methods on Sweet Cherry Fruit Size and Quality
Roberto Núñez-Elisea
Project duration: 2001-2003
Current year: 2002
Original budget request:

Year	Year 1 (2001)	**Year 2 (2002)**	Year 3 (2003)
Total	$4,000	**$6,000**	$7,500

Current year breakdown:

Item	Year 1 (2001)	**Year 2 (2002)**	Year 3 (2003)
Salaries (temporary)	$4,000	**$4,398**	
OPE (0.08 %)		**$352**	
Service and supplies[1]		**$500**	
Travel[2]		**$750**	
Total	$4,000	**$6,000**	$7,500

[1]Spraying equipment, photographic supplies, spray chemicals.
[2] Presentation by PI of research results in national/international scientific meeting (ASHS, ISHS).

CONTINUING PROJECT **YEAR 2**

PROJECT NO.: CH-01-18 (13C-3355-7202)

TITLE: Quantifying Limitations to Balanced Cropping

Principal Investigators: Matthew Whiting
Organization: Irrigated Agriculture Research and Extension Center, WSU-Prosser
Address: 24106 N. Bunn Road, Prosser, WA 99350
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Cooperators: Don Elfving, Horticulturist, WSU-TFREC
Julie Tarara, Research Horticulturist, USDA-ARS

OBJECTIVES:
To determine the effects of stress and management practices such as pruning (dormant and summer), manipulation of canopy architecture (i.e., different training systems), irrigation regimes, and cropload on canopy microclimate (e.g. light environment), carbon fixation and transpiration.

1. To investigate the relationships among tree vigor (i.e., leaf area, shoot growth, trunk expansion, root growth), fruit yield, fruit quality, and yield potential in subsequent years (i.e., flower bud initiation, bloom density, fruit set and yield); in short, investigate whole-tree source-sink relations.

2. To quantify the partitioning of cropping resources, such as photosynthates and nitrogen, between the developing tree canopy, flower buds, and fruits to balance yields with optimized fruit size.

SIGNIFICANT FINDINGS:
- thinning crop load of 'Bing'/Gisela 5 trees improves fruit quality: high quality fruit can be grown on dwarfing, precocious rootstocks
- whole-canopy fruit to leaf area ratio (fruit:LA) is related negatively to fruit size, weight, soluble solids, and unrelated to fruit firmness
- conversely, leaf area per fruit is related positively to fruit quality
- fruit quality declines rapidly at less than 200 cm^2 leaf area per fruit (approximately the equivalent of 5.5 leaves per fruit on a whole-canopy basis)
- high crop load does not influence flower bud initiation in 'Bing'/Gisela 5 trees
- high crop load does reduce the number of flowers *per* flower bud and, as a result, fruiting potential in the following year
- flower bud initiation is not related to vegetative vigor
- tree yield is optimized near 100 – 120 fruit/m^2 leaf area in 'Bing'/Gisela 5 trees
- shoots, leaves, fruit, and lateral growth (*e.g.*, trunk expansion) all compete for limited growth resources during the preharvest interval
- shoot growth is 85 – 90% complete at harvest in 6- and 7-year-old 'Bing'/Gisela 5 trees
- spur leaf area is maximized by 35 – 40 DAFB
- spur LA and shoot LA are related negatively to fruit:LA
- trunk expansion is related negatively to fruit:LA
- carbon supplies are limiting to fruit yield and quality in 'Bing'/Gisela 5 trees
- seasonally, net photosynthesis is highest just prior to harvest and declines tremendously (approximately 50%) soon thereafter

METHODS:
This is a multi-year study in which subsequent experimental treatments will be developed based on the growing foundation of information from each year's studies. Initial experiments will have focused on establishing baselines of whole-canopy carbon balance and treatments to provide a range of cropping levels and fruit size responses.

Acquisition of cropping resources. The laws of supply and demand apply to sweet cherry production. Carbohydrate supply is finite and directly proportional to the rate of photosynthesis. This project has already identified the daily and seasonal trend in whole-canopy net photosynthesis and the effects of crop load and fruiting. In the current year we propose to investigate the extent to which external factors/stresses (*e.g.*, environmental) influence the acquisition of these resources, with the goal of better understanding limiting factors to carbon assimilation and fruit quality. Ultimately, whole-tree carbon budgets will be developed based upon this knowledge. That is, with the understanding of photosynthetic rates and the finite amount of carbon resources and partitioning patterns, how many top quality fruit can be produced? Subsequent studies will examine the effects of:

a. limiting and supplementing assimilate (as by leaf area and/or cropload manipulation)
b. limiting and supplementing nutrient (e.g., nitrogen and water) availability
c. environmental stresses (e.g., temperature, light)

These treatments will be imposed during key developmental stages to determine potential cropping resource effects that impact fruit size. Photosynthetic measurements will be taken using infrared gas analysis and "balloon cuvettes" which enclose the entire tree canopy, thereby integrating photosynthetic activity across all leaves (sun and shade, exterior and interior) for a complete picture of actual orchard tree carbon assimilation. Data will be acquired over 24-hour periods to integrate daylight carbon gains and nighttime respiratory carbon losses. Gas exchange measurements will be related to key physical characteristics (i.e., leaf area and percent light interception) of each tree canopy. This work will determine daily and seasonal carbohydrate production, and quantify carbon resources available for partitioning among competitive growing tissues under 'normal' and stressed conditions.

Partitioning of cropping resources. This project has documented the competitive relationship between vegetative vigor, crop load, and fruit quality in 'Bing'/Gisela 5 trees. Whole-canopy photosynthetic measurements will now be compared among various cherry training systems and rootstock combinations in the high density research orchards at WSU-Prosser's Roza Experimental Unit. This will help quantify cropping potential and photosynthetic efficiency per unit of orchard area. Destructive harvesting of entire trees for carbohydrate and nitrogen analysis of roots, bark, shoots, *etc.* will be performed, as plant materials permit, to quantify treatment (or rootstock) effects on cropping resource partitioning between storage organs.

RESULTS & DISCUSSION:

From the past year's results, we now have a better understanding of the temporal and spatial variability in whole-tree growth and development and the nature of competition for carbohydrate resources. Shoot growth, leaf expansion, and fruit growth all occur during the preharvest interval (*i.e.*, full bloom – harvest) and compete for carbon resources produced during the reactions of photosynthesis. This research has shown that the supply, and/or partitioning of, carbohydrate resources limit fruit yield and quality. As a result, growers must adapt management strategies to improve partitioning to fruit versus other growing points and optimize light interception and effective leaf area. This program will pursue potential techniques (*e.g.*, pruning, growth regulators, water management and thinning strategies) to achieve this goal. In addition, although it was not a goal of

this research to provide thinning recommendations, our results have documented the effect of crop load removal on fruit quality variables and whole-canopy source-sink relations that should contribute to a basis upon which potential thinning strategies can be rationalized.

Since we have shown that carbon supplies are limiting, this project will continue to establish physiological 'baselines' of sweet cherry carbon assimilation and identify influential factors. Moreover, it will also provide a better understanding of the critical periods of cherry tree photosynthesis, nutrient partitioning, flower and fruit development, and competitive organ relationships during growth, resulting in better training and management recommendations to best balance yields with optimized fruit size. Already this project has provided the first quantitative information integrating photosynthetic activity in PNW sweet cherries across the entire tree canopy and within different canopy architectures (Whiting and Lang, 2001). This information becomes more critical as younger and smaller trees with limited canopies and resource storage potential are cropped, either via new rootstocks or intensive cultural practices. Information transfer will continue to occur rapidly through research results reported at industry/extension meetings (*e.g.*, Cherry Institute, Oregon Hort Society, IDFTA), local grower meetings, and publication of results and recommendations in industry (*e.g.*, *Good Fruit Grower*) and scientific (*e.g.*, *Journal of ASHS*, *Scientia Horticulturae*) periodicals.

Literature cited

Whiting, M.D. and G.A. Lang. 2001. Canopy architecture and cuvette flow patterns influence whole-canopy net CO_2 exchange and temperature in sweet cherry. HortScience 36: 691-698.

BUDGET:

Quantifying Limitations to Balanced Cropping
Matthew Whiting
Project duration: 2001-2003
Current year: 2002
Current year request: $42,500*

Year	2001	**2002**	2003
Total	$15,000	**$42,500**	$18,794

Current year breakdown

Item			
Salaries[1]		**5,797**	6,261
Benefits (28%)		**1,623**	1,753
Wages[2]	5,600	**8,000**	8,000
Benefits (16%)	900	**1,280**	1,280
Equipment[3]	4,500	**21,800**	
Supplies[4]	3,000	**3,500**	1,000
Travel[5]	1,000	**500**	500
Miscellaneous			
Total	$15,000	**$42,500**	$18,794

1 One-sixth annual salary for Mr. Efrain Quiroz.

2 4 months student labor (May-August) for assisting with chamber studies, collection of canopy physical data (i.e., leaf area, light interception), and fruit quality analyses

3 Infrared gas analyzer – CIRAS DC ($12,500). Determines CO_2 and water vapor concentration in gas stream. Essential for determination of photosynthetic/transpiration rates. Ceptometer – Accupar by Decagon Devices ($3300). Required for estimation of canopy light interceptance/transmission.
Leaf area meter – CID CI-203 ($5000). Essential for estimation of canopy leaf area. Datalogger multiplexer and environmental sensors– Campbell Scientific AM416 ($1000). Required for collection of environmental data (e.g., PAR levels, leaf and air temperature inside and outside cuvettes)

4 Includes all chamber materials (e.g., mylar, velcro, pvc) and gas analysis consumables

5 Travel to plots

* The current year's request is greater than originally budgeted since a similar equipment request in 2001 was not granted. In addition, I am requesting a portion of my second technician's salary.

CONTINUING PROJECT **YEAR 2**

Title: Nitrogen partitioning in cherry

Project leaders: Anita Nina Azarenko
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Research Assistant: Ann Chozinski, OSU

Cooperators: Tim Righetti
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Wasco Cty Extension, OSU
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The Dalles, OR

John Carter
The Dalles, OR

Objectives

1. To determine the effect of the timing of N fertilizer application on uptake and partitioning of N in sweet cherries.

2. To estimate the contribution of mineralized, fertilizer and recycled N to cherry tree growth.

3. To develop N management strategies that consider the physiology of N uptake in the tree and optimize N uptake from the soil.

Previous work and Significant Findings

Research on pears and apples has shown that N is remobilized from senescing leaves in the fall and stored in perennial tissues over the winter. This stored N is used the subsequent spring for budbreak, flower development and young fruitlet growth. Rapid soil N uptake resumes only during rapid shoot growth and leaf expansion and continues to be taken up into the above-ground portion of the tree until harvest. N applications applied to the soil at harvest and post-harvest is partitioned to roots and is less available in the spring for early tree and fruit growth but is available after rapid shoot growth and leaf expansion begin. Altering the time of fertilizer and methods of applications enables the orchardist to manage vigor and N concentration of tree tissues.

Clearly, cherry trees have different growth and development characteristics than apples and pears. They are harvested much earlier in the growing season than other deciduous fruit crops. We do not know much about the dynamics of N uptake nor the efficiency of N uptake especially after harvest. Some N uptake may be occurring but it may be stored in the roots, and therefore, if like apple and pear, little N would be available for early growth of leaves, shoots, flowers and young fruit the

following year. Another unknown is how efficiently is N taken up after harvest. Additionally, soil mineralization of N is at its optimum from June through September. If limited soil uptake of N is occurring after harvest, mineralization of N from the soil would potentially contribute to sources of non-point source pollution. Therefore, the question of greatest concern is when and where is N moved in the tree, especially during the post-harvest growing season. Should little N be taken up into the above-ground portion of the tree after harvest then, N applications and orchard floor management practices should be adjusted to reduce the potential for N leaching while increasing the N status of the tree for the subsequent year's spring growth. Since there is very little published information on N uptake and partitioning in cherries and because of the potential of mid-summer N leaching, we proposed last year, and wish to continue research this year, to determine the effect of fertilizer timing on the uptake and distribution of N in sweet cherries, estimate the mineralized and recycled components and develop N management strategies based on these findings.

We began this project in 2001. Labeled N was applied to fruiting cherry trees, supplied by John Carter, at the beginning of May (rapid shoot growth phase), beginning of June (pre-harvest), beginning of August (post-harvest) and end of September (pre-leaf fall). Fall foliar urea was applied at the beginning of October. Trees were harvested and leaf samples were collected during the growing season. Four replicate trees of each treatment were excavated in the middle of October. Trees were partitioned into current season's growth; spurs; shoot and spur leaves; one, two and three year old wood; scaffold; trunk; and roots. Components were weighed, sub-sampled and subsequently dried. Samples have been sent for N analysis. Another set of four replicate trees will be grown through next year to ascertain how the timing of N application affected the recycling of N into the tree the subsequent year.

An additional study was begun to determine the contribution of mineralizable N to the total N pool in the trees. A total of 32 trees were selected for this study. Eight of the trees were fertilized with labeled N in the spring and another eight in the summer. The remaining 16 trees were fertilized with unlabeled N, ½ in spring and ½ in the summer. Next year, treatments will be applied that will enable the determination of the contribution of recycled, fertilizer and mineralized N to the N content in the tree.

Procedures/Methods:

Under objective 1. Four N treatments were applied to the soil around the base of four replicated, mature, bearing cherry trees per treatment. The dates of application were May 10, June 8, August 3 and September 26, 2001. Labeled nitrogen (^{15}N) in the form of ammonium sulfate fertilizer was applied to the soil. A post-harvest foliar urea application was applied in the beginning of October. Fruit yields were obtained and fruit samples were taken for N content and ^{15}N analysis in 2001 and will also be obtained in 2002. Shoot and spur leaves were sampled at the end of July. One set of trees (24 trees) will be excavated at the end of October, partitioned, and analyzed for N content and ^{15}N. Efficiency of uptake will be calculated as well as N and dry matter partitioning. The remaining set of 24 trees will receive unlabelled N in spring 2002, harvested, leaves sampled and trees dug and partitioned in fall 2003. Again, N content and ^{15}N distribution will be determined. Data will be evaluated and summarized.

Under objective 2. The following treatment combinations will have been applied to four trees each by mid- summer 2002.

2001	2002
Spring application	
Labeled N	Unlabeled N
Labeled N	No fertilizer
Unlabeled N	Label
Unlabeled N	No fertilizer
Post-harvest application	
Labeled N	Unlabeled N
Labeled N	No fertilizer
Unlabeled N	Label
Unlabeled N	No fertilizer

Trees will be harvested. Leaf samples taken. Fruit and leaves analyzed for N content and label. In October, the 32 trees will be dug, partitioned, weighed, sub-sampled, and analyzed for N content and label.

Under objective 3. Current N fertilizer recommendations will be re-evaluated. Recommendations and extension publications will be revised according to the research findings. Results will be submitted for publication. The research results and interpretation of the data will be posted on the Oregon's fruit and nut orchard network.

Budget Requested:
Nitrogen partitioning in cherry
Project leaders: Anita Nina Azarenko

Estimated duration of study: At least one more year
Current Year: 2002

Year	**2001**	**2002**
Total	$7,500	**$10,300**
Item		
Wages	3,900	**3,900**
Benefits (%)	200	**195**
Equipment		
Supplies	2,000	**1,000**
Travel	400	**405**
Sample analysis	1,000	**4,800**
Total	**$7,500**	**$10,300**

CONTINUING PROJECT **YEAR 2**

Project Number: 13C-3361-4795

TITLE: Epidemiology and control of stone fruit powdery mildew (increased emphasis on cherry powdery mildew)

Principal Investigator: G. G. Grove, Plant Pathology, WSU-IAREC, Prosser, WA

OBJECTIVES:

> Determine if irrigation management can be used to delay the onset of cherry mildew epidemics and/or reduce disease severity.

> Continue large plot (on-farm) testing of oil-based weather driven cherry powdery mildew management program.

> Continue implementation of the phenology, symptom, and irrigation-based spray oil program for cherry powdery mildew.

> Continue evaluating various sprayer technologies

> Investigate the influence of weather variables and current irrigation practices on aerial conidia populations of conidia of the cherry and peach mildew fungi.

> Continue field evaluations of various "soft" fungicides for efficacy against stone fruit mildews and as components of antiresistance strategies for maintaining the effectiveness of "at risk" fungicides.

> Continue the development and implementation of practical fungicide resistance management programs.

> Evaluate new and novel spray technologies for mildew management on Bing, Rainer, and Sweetheart cherries.

> Evaluate growth regulators as a means of reducing disease pressure via management of vegetative vigor.

> Develop an epidemiological-based method of timing fungicide sprays for managing cherry and peach/nectarine powdery mildew.

Significant findings:

- Timing the initial oil fungicide applications according to early symptoms/signs provided control superior to that provided by a phonological approach.

- Delaying the initial irrigation had significant effects on mildew severity, sucker quantity, fruit soluble solids, and fruit weight. The effects on fruit size are unclear.

- Timing the initial DMI fungicide application according to initial irrigation resulted in mildew control superior to phenology based sprays

- Excellent powdery mildew control was attained using a program free of DMI and Strobilurin fungicides. Trial was conducted in an orchard under extreme disease pressure.

- Several biological (e.g. Serenade) or SAR (Vacci-Plant and Messenger) compounds were ineffective for powdery mildew control.

- No phytotoxicity was observed when Lapins, Stella, or Sweetheart cherries were repeatedly treated with narrow-range petroleum oils (Stylet Oil) in the nursery.

- Quinoxyfen, Stylet Oil, and Trilogy, applied alone or in combination, provided mildew control superior to that obtained using DMI fungicides.

Methods:
Cherry Mildew:
Continue developing practical fungicide resistance management strategies. Various combinations and rotations of DMI, quinoline, strobilurin, SAR, oil, and sulfur compounds will be applied to Bing, Rainier, Van, Lapins, and Sweetheart cherries and evaluated for efficacy and phytotoxicity. Compounds will be applied in calendar and weather based management programs. Disease incidence and severity will be determined by randomly selecting five terminal shoots from each plot, and picking five leaves from each terminal starting with the last fully open leaf and working down the shoot for a total of 25 leaves per plot. The percentage of the surface area of the underside of each leaf infected by mildew will be estimated and recorded. Data will be subjected to analysis of variance and means separated according to Fisher's PLSD at $P < 0.05$.

Irrigation studies. Investigations will be continued by delaying irrigation in portions of a cherry orchard with a history of severe powdery mildew. Foliage produced on or near bark fissures will be periodically inspected with a hand lense in order to ascertain the timing of primary infection. Several weeks later, disease incidence and severity will be determined by randomly selecting 10 terminal shoots on each tree and determining the percent leaf area colonized on each of ten leaves beginning at the first fully expanded leaf beneath the shoot apex. Data will be subjected to analysis of variance and means separated according to Fischer's Protected LSD at $P < 0.05$. For long term studies of the effects of irrigation type and duration on primary infection, secondary infection, and overall disease pressure, an orchard consisting of drip, micro sprinkler, and under tree impact sprinklers will be established at WSU-IAREC. The effect of irrigation type on orchard microclimate and airborne spore concentrations will be studied using CR-21X Dataloggers and volumetric spore traps.

Sprayer Technology. Mildew control using electrostatic sprayers will be evaluated in Wenatchee, Pasco, and Prosser orchards with histories of powdery mildew. Conventional spray technology will serve as controls. Fluorescent dyes will be used to assess spray coverage. Replicated trials comparing mildew control using curtain, electrostatic, and conventional air blast equipment will be conducted in Prosser.

Oil phytotoxicity issues. Expand investigations on control of mildew with oils. Phytotoxicity issues will be addressed in nursery trials. Lapins, Stella, and Sweetheart cherries will be treated with various concentrations of Omni and Stylet Oil alone and in combination with insecticides used for cherry fruit fly management.

Forecasting. Continue development of oil-based phenology and symptom/weather-driven cherry mildew management program. Wenatchee, Yakima, Pasco, and The Dalles orchards with histories of repeated powdery mildew epidemics will be used for this portion of the study. Portions of orchards will be treated using conventional spray programs while separate portions will be treated using the oil programs. Foliar disease incidence and severity at harvest will be determined as described previously.

Results and Discussion

Management of cherry mildew was improved by timing the initial fungicide application when either 1) the first irrigation was applied or 2) the first signs of powdery mildew appeared provided resulted in a significant reduction of mildew severity (Table 1). Furthermore, in two cases this improvement was obtained using no DMI or strobilurin fungicides. Oil applications were limited to no later than pit hardening. A potential shortfall in the Sulforix (calcium polysulfide) treatments was the requirement for a short (7 day) spray interval; it was imperative that Sulforix be applied at 7- day intervals. *DMI fungicides will no longer be considered viable chemical alternatives in this particular orchard.*

The rational for delaying the initial irrigation set was to postpone primary infection in order to shift the explosive phase of cherry mildew epidemics to later in the season. In our trial, delaying the initial irrigation set 1 week reduced powdery mildew severity (Table 2). Irrigation delays of 1-3 weeks also had significant effects on fruit soluble solids, fruit weight, and sucker length (Tables 3,4). The effects on fruit size are less clear.

The SAR and other biological compounds failed to adequately control powdery mildew.

Table 1. Severity of cherry powdery mildew when timing the initial fungicide application according to the initial appearance of symptoms[a], initial irrigation[b], or phenology[c], Wenatchee, WA 2001. Means followed by common letters are not significantly different according to Fischer's Protected LSD ($P = 0.05$).

Treatment	**Disease severity[d]**
Oil first symptoms, then Sulforix (7d)[a]	7.3 a
Rubigan 24 hr after irrigation, then Sulforix (7d)[b]	8.7 a
Oil SF, SF + 14, then Trilogy (2 applications)[c]	9.6 ab
Trilogy SF, then every 14 days[c]	13.4 bcd
Rubigan 24 hr after irrigation, the Rally: Procure alternation[b]	21 cd
Oil first symptoms, then Rally : Procure alternation[a]	22.7 cd
Oil SF, SF + 14, then Rally (2 applications)[c]	23 d
Rubigan 24 hr after first irrigation, then Sulforix (14 d)[b]	23.5 d
Oil at first symptoms, then Sulforix (14 d)[a]	25.2 d
Rubigan 24 hr after irrigation, then Rally: Abound[b]	25.4 d
Untreated control	42.9 e

Table 2. Cherry powdery mildew severity in a Pasco, WA cherry orchard where the initial irrigation set was delayed 1-3 weeks.

Irrigation Delay	**Mildew severity**
None	23.1 b
1 week	16.0 a
2 weeks	12.9 a
3 weeks	12.2 a

Table 3. Fruit weight, fruit soluble solids, and sucker length, in a Pasco, WA cherry orchard where the initial irrigation set was delayed 1-3 weeks.

Irrigation Delay	**Weight**	**Soluble solids**	**Sucker length**
Normal	902.9 b	17.0 a	32.9 a
1 week	768.1 a	15.2 a	36.8 b
2 weeks	874.0 ab	16.6 a	32.0 ab
3 weeks	785.1 a	17.7 b	28.9 a

Table 4. Percentage of 10-row cherries in a Pasco, WA cherry orchard where the initial irrigation set was delayed 1-3 weeks. Raw and transformed data are presented.

Irrigation Delay	**Percent 10 row cherries (raw %)**	**Transformed (%)**
None	41.6 a	5.9 ab
1 week	19.6 a	4.0 ab
2 weeks	47.2 a	6.8 b
3 weeks	17.2 a	3.7 a

BUDGET:
Epidemiology and control of stone fruit powdery mildew (increased emphasis on cherry powdery mildew)
G. G. Grove
Project duration: 2001-2005
Current year: 2002
Original budget request:

Year	**Year 1 (2001)**	**Year 2 (2002)**	**Year 3 (2003)**
Total	$71,228 (all tree fruit)	**$67,136 (stone fruit only)**	$69,243 (stone fruit only)

Current year breakdown:

Item	**2001**	**2002**	**2003**
Salaries[a]	$32,635	**$43,266**	$44,997
Benefits (%)	$9,137	**$9,398**	$9,774
Wages	$6,100	**$8,424**	$8,424
Benefits	$976	**$1348**	$1348
Equipment	$17,680	**-**	-
Supplies			
Travel[b]	$4,700	**$4,700**	$4,700
Miscellaneous			
Total	$71,228	**$67,136**	$69,243

[a]12,636 (fringe: 3,538) Jeff Lunden, $15,114 (fringe $1.360) graduate research assistant; $15,516 (fringe $4,500) technical farm employee (Ephraim Quiroz)
[b] project will involved plot work in Chelan, Okanogan, Franklin, Benton, Grant, and Yakima Counties

CONTINUING PROJECT **YEAR 2**

WTFRC Project #: CH-01-14, **Organization Project #: 13C-3361-5291**

Project title: Protecting Pacific Northwest cherry orchards from serious virus threats.

Principal Investigator: Ken Eastwell, Assoc. Plant Pathologist
Organization: Washington State University – IAREC, Prosser

Co-Investigators: Bill Howell, Manager NRSP-5, WSU-Prosser

Cooperators: Lauri Guerra, Washington State Dept of Agriculture, Prosser
Hassan Mojtahedi, Research Associate, WSU-Prosser
Jerry Uyemoto, USDA-ARS, Davis, CA
Gene Milbrath, Oregon State Dept of Agriculture, Salem, OR

Funding History: FY2001 - $20,000

Project Objectives:

1. Develop a strategy to control the rapid decline of cherry trees associated with *Cherry leafroll nepovirus* (CLRV).
FY2002: a) Determine transmission mechanisms for CLRV in orchards of the Pacific Northwest.
b) Determine factors that affect disease development associated with CLRV.

2. Determine the biology of an emerging and very severe virus disease of cherries in the Columbia River Valley.
FY2002: a) Determine sources of an emerging virus disease in Central Washington and the impact of these diseases on commercial cherry varieties and rootstocks.
b) Develop improved methods for virus detection.

Significant findings:
Project Objective 1:

- The rapid decline of trees induced by *Cherry leafroll virus* (CLRV) is associated with mixed infections of CLRV plus one or more of the *Ilarviruses* that are common in Pacific Northwest cherry orchards (i.e., *Plum American line pattern*, *Prunus necrotic ringspot* and *Prune dwarf ilarviruses*).
- CLRV is distributed throughout the Yakima Valley and the lower portion of the Columbia river basin. A limited survey reveals no occurrence of CLRV in the mid-Columbia basin.
- Most trees exhibiting significant CLRV-induced decline are 12 to 25 years old.
- The cherry isolate of CLRV is not detected in Oregon or California.
- No CLRV is detected in registered mother trees in nurseries participating in the Washington certification program.
- CLRV is pollen-borne. This does not necessarily mean that the virus is pollen transmitted.

Project Objective 2:

- The appearance of virus symptoms associated with a novel virus is very rapidly spreading to other cherry trees in the mid-Columbia basin.
- Rapid tree decline is most severe on trees with 'Montmorency' (*Prunus cerasus*) interstock. This interstock exhibits severe stem pitting and grooving.
- The virus belongs to a group of viruses for which there are no known vectors.

Results and discussion:
Cherry production underwent an ambitious revitalization program during the early 1950's. To restore productivity of an ailing industry, trees affected with virus-like diseases were removed throughout the Northwest cherry growing districts. With the advent of certification programs in the early sixties, the incidence of virus diseases abated significantly. However, the emergence of new viruses and the resulting reduction in yield continues to challenge the profitability of cherry production in the Northwest.

Objective 1: The rapid decline of mature and otherwise productive sweet cherry trees caused by infection by *Cherry leaf roll virus* (CLRV) is occurring in orchards of the lower Yakima Valley. Initially, trees infected with CLRV display moderate disease symptoms. Delayed fruit ripening and modest fruit size complicates orchard management. However, after a few seasons, or when the trees become infected with an *Ilarvirus*, the trees begin a rapid and more severe decline resulting in tree removal. Destruction of mature trees is a severe economic loss for any grower.

The walnut isolate of CLRV is known to be widespread in walnut where it induces significant financial losses, but our discovery of the cherry isolate of CLRV was the first in this continent. Consequently, we are trying to very quickly learn critical information that growers need in order to manage their orchards effectively. It is not known how widespread CLRV is, the source of virus, or whether it is continuing to spread naturally between or within orchards. We are obtaining baseline data so future spread of the virus can be monitored, and so management strategies can be developed.

This year we did extensive virus testing to determine the distribution of CLRV within infected trees, and to determine the most appropriate sampling methods for virus detection. This included determining the part of the season when virus detection is most reliable, the type of tissue that provides the most reliable results and the number of samples that must be collected from each tree for accurate detection. This critical information was then used as the basis for all subsequent tests.

We conducted over 2300 virus tests on targeted samples collected from Washington, Oregon and California to reveal the distribution of the virus within these major cherry production regions. Of the 257 trees sampled in Oregon and the 277 trees sampled in California, no tests were positive for CLRV. In Washington, 828 trees were sampled representing 48 separate production blocks of sweet cherry. CLRV-infected trees were found in 22 or 46% of the blocks in Washington. The major goal of the survey was to gain some sense of the geographical distribution of the virus within the State, not the number of infected trees. There are many more CLRV-infected trees that were not sampled and were not among the 112 confirmed infected trees detected during this targeted survey. The infected trees were in blocks throughout the lower Yakima River Valley and the lower Columbia basin ranging from Union Gap to Finley. Within these blocks, the incidence of CLRV ranged from less than 1% to 32% of the trees infected. In addition, registered mother trees in the WSDA Certification program were tested for CLRV, and all were free of this virus.

Of the infected trees, the vast majority of trees were in established orchards ranging in age from 12 to 25 years old. CLRV was detected in only three trees that were 6 years old or less. A similar number of trees older than 30 years were CLRV-infected.

At present, we don’t know if this virus is spreading naturally between and/or within orchards. As part of creating a baseline from which to monitor virus spread, large sections of three blocks were mapped in great detail. Every tree was tested for CLRV plus three common ilarviruses. These blocks will be retested annually to determine the rate of spread of CLRV.

Our previous research has confirmed that pollen from CLRV-infected trees is ELISA-positive. However, it is not known if the virus in this form is infectious. We collected fruit from trees that are non-infected but flanked by infected pollenizers. Fruit was also obtained from infected trees flanked by non-infected pollenizers. In the former case, none of the fruit had detectable virus in the flesh, but virus was detectable in many of the pits, ranging from 0 to 26%. Thus, the pollen is able to carry the virus to adjacent trees and the virus can be found in the seed. Further testing is required to determine if the seedlings are infected with CLRV. When the maternal tree in virus-infected, flesh of all fruit was virus-infected, and 76% of pits contained detectable virus.

The revelation that a non-infected tree can produce fruit of which 26% contains virus is significant. The relatively large numbers of fruit that contain CLRV indicates that the healthy tree is being assaulted with large amounts of virus-infected pollen. Despite this, the tree remained free of detectable virus. The virus status of this group of trees has been known for three years and has remained unchanged during that period. Thus, if infection of mature trees does occur through interaction with virus-laden pollen, then such transmission occurs with very low frequency.

Possible pollen and seed transmission are important issues that need to be resolved. The ability to transmit the virus to other mature trees could explain the erratic distribution of the virus in the Yakima Valley. If this scenario were correct, then the grower would adopt a strategy of careful testing and rouging to slow the spread of the virus to adjacent trees. If the virus does not spread naturally in the orchard setting, then the trees could be left in place until individual trees are no longer productive. If the virus is transmitted from pollen to seed, then stringent precautions must be taken in the production of seedling rootstock.

Objective 2: As reported last year, a second virus disease has emerged in Central Washington. We have very limited knowledge of the disease or the virus at this time. Disease expression is apparently very dependent on the environment. During the previous three seasons of observation, the virus induced severe die back of shoot tips and even major scaffold limbs, leaf loss, small fruit that is late ripening and dramatic foliar symptoms. Unexpectedly, the leaf symptoms observed this season are subdued, and relatively few shoots were observed with tip die back. Within 4 years, this disease spread through an otherwise productive 12-year old sweet cherry orchard and more than 170 mature trees removed. Continued monitoring is essential to determine the potential long-term impact of this virus. Methods must be developed to diagnosis of the virus so those affected growers can initiate appropriate and effective control measures. Current methods are prohibitively expensive and technically demanding.

This unknown virus appears to emerge adjacent to grassland steppe common in Central Washington. Based on the assumption that the virus is moving into orchards from native vegetation, we collected specimens of perennials from areas next to the affected orchards. These specimens were identified and tested for the presence of the virus. At least three specimens of each were tested for the virus and no virus was detected. The species collected included: *Alnus incana* (alder), *Purshia tridentat* (antelope bitterbrush), *Populus angustifolia* (narrowleaf cottonwood), *Populus trichocarpa* (black cottonwood), *Salix exigua* (coyote willow), *Salix* spp. (likely golden willow), *Salix* spp. (likely peachleaf willow), *Ulmus pumula* (Siberian elm), and *Ulmus americana* (American elm). Thus, the presence of this virus in native vegetation remains unconfirmed.

Clearly, viruses are not involved in every case of orchard decline. However, it is important to recognize when viruses induce or contribute to tree decline or mortality. The research in this proposal will investigate the viruses associated with the decline of cherry orchards in the Northwest and develop appropriate disease control measures for commercial growers.

Methods:

Objective 1a) Determine transmission mechanisms for CLRV in orchards of the Pacific Northwest. Three modes of transmission could account for the distribution of CLRV that is observed in orchards. Each of these is being examined to obtain their relevance to the Pacific Northwest. 1) Seed transmission (Cooper *et al.*, 1984) could be important in the production of seedling rootstocks. Mature fruit was purchased from affected growers, and the seed recovered. Virus content of 650 fruit and seeds was determined by ELISA. The remaining seed is being stratified and germinated. The seed transmission rate of other viruses can be greatly affected by whether the seed is dried or not before stratification. Thus, the seed lots were split. One-half of each lot was dried before being stratified while the remainder was stratified directly. Germination rates will be measured and compared to non-infected seed. Emerging seedlings will be tested for CLRV in the spring and autumn of 2002 to determine the frequency of seedling transmission. 2) Nematode transmission is known to occur for other viruses of this group. A suspected vector, *Xiphinema revesi*, has been identified in several of the affected orchards. Since it is difficult to maintain this nematode in controlled greenhouse studies, trap plants will be planted directly into affected orchards to demonstrate if the nematodes are able to transmit the virus from infected cherry trees to trap plants. It has been demonstrated that CLRV moves very slowly or not at all through 'Colt' rootstock Rowhani & Mircetich, 1992). To evaluate the influence of rootstock on CLRV transmission, we have planted 25 'Bing' on 'Colt' and 25 'Bing' on 'Mazzard' in orchards that have been mapped for CLRV. The disease status of these trees will be monitored over the next several years to see if they become infected, and if there is a difference between the rate at which trees on 'Mazzard' versus 'Colt' rootstock become infected. If CLRV is transmitted exclusively through the soil, then trees on 'Colt' rootstock should remain healthy. 3) CLRV occurs in pollen grains from infected trees (Massalski & Cooper, 1984; plus our observations). It is possible that pollen could play a role in transmission. The possibility of pollen transmission will be determined through continued observation and testing of healthy non-infected maternal trees flanked by CLRV-infected pollenizers.

Objective 1b) Determine conditions affecting the disease development associated with CLRV. In all of the orchards that we surveyed, the scenario is similar. Infected trees about 12 to 25 years old suddenly began a spiral of decline leading to tree removal. Infection by CLRV alone is not overtly apparent. Despite the lack of dramatic foliar symptoms, most infected trees are visibly affected. Bloom is delayed, fruit set is heavy, ripening is delayed, and fruit is smaller and of lower quality. Interestingly, one tree that has been inffected with CLRV for at least three years does not shown any adverse effect. It is known that other viruses of the same genus as CLRV can harbor small infectious agents that significantly moderate disease symptoms. Therefore, we propose to characterize and compare the CLRV from this non-symptomatic tree to CLRV isolated from symptomatic trees in the hope of identifying such as agent. If found, it could be used to reduce the symptoms of cherry trees infected with CLRV.

Through our investigations, it appears that tree decline becomes very severe in CLRV-infected trees when they become infected with *Prunus necrotic ringspot virus*. Secondary infection of *Prune dwarf virus* also increases the severity of CLRV-induced symptoms. Both of these viruses are endemic in the Pacific Northwest and most cherry orchards become infected with these viruses as they mature.

Objective 2a) Determine sources of an emerging virus disease in Central Washington and the impact of these diseases on cherry varieties and rootstocks. Specimens of native plants that are most likely to serve as natural reservoirs of the virus have been established in the greenhouse. These include antelope bitterbrush, hawthorn, wild rose, Amelanchier, bitter cherry and chokecherry. Potted specimens will be inoculated with bark patches from infected cherry trees. They will be monitored closely for the appearance of symptoms and tested for their ability to support virus infection.

We propose to inoculate several rootstock/cultivar combinations to determine which are sensitive and tolerant. The use of resistant or tolerant selections could provide one strategy for permitting continued cherry production in affected areas of the Pacific Northwest.

Objective 2b) Develop improved methods for virus detection. To facilitate further studies on the source and movement of this virus, more appropriate testing methods are required. We propose to isolate the gene for the virus coat protein and express it in bacteria. The isolated protein will be used to produce antibodies. If successful, this strategy will provide the reagents for a serological test that is amenable to routine testing of large numbers of samples.

References:

Cooper JI, Massalski PR, Edwards M-L. 1984. Cherry leaf roll virus in the female gametophyte and seed of birch and its relevance to vertical virus transmissions. *Annals of Applied Biology* 105:55-64.

Massalski PR, Cooper JI. 1984. The location of virus-like particles in the male gametophyte of birch, walnut and cherry naturally infected with cherry leaf roll virus and its relevance to vertical transmission of the virus. *Plant Pathology* 33:255-262.

Rowhani A, Mircetich. 1992. Mechanical transmission, susceptibility, and host response in Bing sweet cherry and three rootstocks by the walnut strain of Cherry leafroll virus. *Plant Disease* 76:264-266.

Budget: Protecting Pacific Northwest cherry orchards from serious virus threats.
Ken Eastwell
Project duration: 2001-2003
Current year: 2002

Year	Year 1 (2001)	**Year 2 (2002)**	Year 3 (2003)
Total	22,040	**25,465**	26,739

Current year breakdown:

Item	Year 1 (2001)	**Year 2 (2002)**	Year 3 (2003)
Salaries	9,465	**12,012**[1]	12,492
Benefits	2,744	**4,084**[2]	4,247
Wages	---	**---**	---
Benefits	---	**---**	---
Equipment	---	**---**	---
Supplies	7,791	**9,369**[3]	10,000
Travel	---	**---**	---
Miscellaneous	---	**---**	---
TOTAL	20,000	**25,465**	26,739

1 Salaries: 0.35 FTE Associate in Research; 2 Benefits: 34% of salary; 3 Supplies and services:

Objective 1:
RT-PCR testing of seedlings (200 trees at $20/tree - supplies only) $4,000
Greenhouse expenses (soil, pots, plants, fertilizer etc.) 275
ELISA tests (50 tests at $6.38 each) 319
Molecular characterization of CLRV isolates (cloning & sequencing) 2,500

Objective 2:
Greenhouse costs (soil, plants, pots etc.) 275
RT-PCR tests (200 samples at $10/sample - supplies only) 2,000
TOTAL **9,369**

Additional funding sources:
Funding was received from USDA-CSREES Critical Issues fund to support research on "*Cherry leafroll virus* Control and Management". The total funding of $31,667.99 is provided for one year (from March 1, 2001 to February 28, 2002). This funding was essential to allow us to perform the tri-State CLRV survey and the development of appropriate sampling and testing strategies. Research and tests costs for year 2002 are shared with funds from this grant.

FINAL REPORT

WTFRC Project # *WSU Project # 13J-3661-5367*

Project Title: Epidemiology and Control of Bacterial Canker in Sweet Cherry

PI: Chang-Lin Xiao, Assistant Plant Pathologist
Organization: WSU-TFREC, Wenatchee

Co-PIs: Gary Grove, Associate Plant Pathologist, WSU Prosser
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Objectives:

1. Conduct field surveys to determine the occurrence of bacterial canker in eastern Washington State.

2. Collect bacterial strains from various locations and determine the copper sensitivity (or resistance) of *P. syringae* populations in sweet cherry orchards.

3. Evaluate chemical products for control of the disease.

The original proposal was not fully funded. The objectives listed above were in the modified proposal.

Significant Findings:

1. Bacterial canker occurs at low incidence among cherry blocks surveyed in the Yakima and Wenatchee areas, but severe epidemics have been observed at some specific sites. Bacterial canker is more noticeable in the northern fruit production areas from Pateros to Oroville.

2. Young trees (1 to 5 years old) are more prone to infection by *Pseudomonas syringae*. The disease was found in 2 of 24 young blocks in the Yakima area, 4 of 19 in the Wenatchee area, and 12 of 28 in the northern area.

3. The strains of *Pseudomonas syringae* isolated from cherry orchards exhibited varying levels of tolerance to copper, with 82% of strains having tolerance to copper at 0.25 mM $CuSO_4$ in vitro tests.

Funding Request:

No funding is requested. We are not continuing this project because of the current low level of the disease in most commercial orchards and lack of interest in the industry in funding a full program on this disease. However, as the acreage of new plantings increases, particularly those susceptible varieties, bacterial canker can be an important factor in the process of establishing profitable young orchards. We will key an eye on this disease.

Methods:

1. **Orchard survey.** The survey for bacterial canker was conducted in the Yakima Valley, Wenatchee area, and the northern fruit production region from Pateros to Oroville. Forty-two cherry orchards or blocks in the Yakima area, 20 in the Wenatchee area, and 40 in the northern

production region were randomly selected for this survey. The survey mainly focused on the young orchards. In each block, 60 trees were selected for examining bacterial canker symptoms.

2. **Isolation and copper sensitivity test** of ***P. syringae*.** In the spring, branches exhibiting canker symptoms and diseased buds were collected from nine orchards listed in Table 1.

Table 1. Sweet cherry orchards sampled for testing copper resistance of *Pseudomonas syringae.*

Site	Variety	Age	History of copper sprays	Type of samples
1	Rainier	5 years	NA[a]	Diseased and healthy buds
2	Lapins	6 years	NA	Diseased buds
3	Rainier	2 years	NA	Diseased buds
4	Chelan cherry on Mazzard	3 years	13.7 Kg/ha KOCIDE 10 % lime and sulfur solution Once in spring	Diseased buds
5	2009s on Mazzard	3 years	13.7 Kg/ha KOCIDE 1.18 L/ha NU-FILM 17 Once in both spring and fall	Diseased buds
6	2525s and 4348s on Mazzard	5 years	13.7 Kg/ha KOCIDE 1.18 L/ha NU-FILM 17 Once in both spring and fall	Diseased buds
7	Sweetheart on Mazzard	7 years	13.7 Kg/ha NU-COP 1.18 L/ha NU-FILM 17 Once in both spring and fall	Diseased buds
8	Chelan cherry on Mazzard	3 years	13.7 Kg/ha KOCIDE Twice in spring 2000 And Once in spring 2001	Diseased buds
9	Bing	8 years	Copper product once in both spring and fall	Diseased buds

[a] Detailed spray information not available but copper products were applied.

Samples were placed in zip lock bags, transported to the laboratory in a cooler and kept in a cold room until processed. Most bacterial strains were isolated from diseased buds. To isolate bacteria, outer bark tissues of selected buds were removed with a sterile scalpel, and small segments were excised from the buds. The excised segments were surface-disinfected for 30 seconds in 10% bleach and rinsed three times with sterile deionized water. Excised segments were then soaked in 5 mL of sterile potassium phosphate buffer (pH 7.0, 12.5 mM) with continuous rotary shaking (250 rpm) for 2 hours at 23°C. Serial dilutions (1/10, 1/100, 1/1000) in sterile water were made from the washings and plated onto King's medium B agar (KB). Plates were incubated at room temperature for four days and examined for fluorescent colonies under 366 nm (long wavelength) ultraviolet light. Representative fluorescent colonies were selected, purified on KB, and tested for the oxidase activity and the presence of arginine dihydrolase. Bacterial strains were stored in 0.01 M phosphate buffer at 4°C or in tryptic soy broth containing 15% glycerol at –80°C.

To assay copper tolerance in culture, modified low-complexing mineral salts medium, casitone-yeast extract-glycerol medium (CYE) was used for these assays. Copper from a stock solution of $CuSO_4$ was added to autoclaved CYE medium cooled to 50°C immediately before pouring to achieve the desired copper concentrations of 0, 0.25, 0.5, 1 and 2 mM of $CuSO_4$. Copper gradient media was prepared by dispensing 15 ml of CYE amended with cupric sulfate in 100 X 15-mm Petri dish plates. After the medium solidified, the dishes were placed in a horizontal position. Gradient plates were stored at 4°C for at least 8 hours before use.

Bacteria were grown in test tubes each containing 4 ml of tryptic soy broth (Difco, Detroit) on a rotary shake incubator at 250 rpm at 23˚C. Preliminary tests showed that after 4 hours in soy broth, a 1000-fold diluted bacterial suspension resulted in approximately 10^6 cfu/ml. One hundred µl of such bacterial suspensions of each test strain was spread on a plate containing the copper-amended CYE medium. Three replicates of each copper concentration were included in the experiment for each isolate. Plates were incubated at 21°C for 72 hr in an inverted position, after which visible confluent growth of a bacterial strain on copper-amended CYE medium was considered copper-resistant at the corresponding concentration of $CuSO_4$.

3. **Chemical control of bacterial canker.** Lime sulfur and copper products are commonly used on cherry trees in the fall or early spring. Mixture of copper products and mancozeb has been reported to enhance the bactericidal activity of copper products for control of bacterial diseases on other crops. In the fall of 2000, we set up a field trial in a commercial orchard to evaluate effects of lime sulfur, copper hydroxide, copper sulfate, mancozeb, and the mixture of copper hydroxide and mancozeb on control of bacterial canker. Seven treatments were included in this trial: (1) lime sulfur in the fall and spring; (2) lime sulfur in the fall and copper hydroxide in the spring; (3) copper hydroxide in both fall and spring; (4) copper sulfate in both fall and spring; (5) mancozeb in both fall and spring; (6) mixture of copper hydroxide and mancozeb in both fall and spring; and (7) unsprayed control. Treatments were arranged in a randomized complete design, with 3 replicates (two trees for each treatment within each replicate).

Results and Discussion:

1. A total of 42 cherry blocks were surveyed in Yakima area. Bacterial canker was found in four blocks with different ages. Of 24 blocks at age of l to 5, two had bacterial canker, with mean incidence (percentage of trees with the disease) of 3%; of the 11orchards at age of 6 to 10, one had bacterial canker with a disease incidence of 2%; and among 7 blocks at age of more than 10 years, one block under the cover had bacterial canker with the incidence of 2% (Table 2).

In the Wenatchee area, of the 19 blocks at age of 1 to 5, four had bacterial canker, with mean disease incidence of 3% (Table 2).

In the northern fruit production area, 40 blocks were surveyed and bacterial canker was found in 18 blocks. Bacterial canker was more noticeable in the region. Among the 28 blocks at age of 1 to 5, 12 had bacterial canker (43% of the blocks), and the incidence of disease in these blocks ranged from 2% to 77% with mean incidence of 14%. Of the eight blocks at age of 6 to 10, five had bacterial canker, with mean disease incidence of 6% (Table 2).

Table 2. Summary of orchard survey of bacterial canker on cherry trees in eastern Washington.

Production [a] Region	**Age of Block**	**Number of orchard surveyed**	**Number of orchard with the disease**	**Incidence of disease (%) in the orchards with the disease [b]**	
				Range	**Mean**
Yakima	1 – 5	24	2	3 – 3	3
	6 – 10	11	1	2	2
	> 10	7	1	2	2
Wenatchee	1 – 5	19	4	2 – 5	3
	6 – 10	1	0		
	> 10				
Northern Area	1 – 5	28	12	2 – 77	14
	6 – 10	8	5	3 – 10	6
	> 10	4	1		5

[a] The Yakima survey included the following areas: Moxee, Union Gap, Parker, Buena, and Zillah. The Wenatchee survey included Wenatchee, East Wenatchee, Rock Island, and Rocky Reach Dam. The northern area included Pateros, Brewster, Bridgeport, Okanogan, Omak, Tonasket, and Oroville.

[b] The incidence of disease was expressed as percentage of trees exhibiting bacterial canker symptoms in the orchards. Sixty trees were examined for the presence of the disease in each block.

2. Nine orchards with a history of bacterial canker disease were selected to be monitored for copper resistance of *Pseudomonas syringae* populations. A total of 110 *Pseudomonas syringae* strains were isolated and tested for resistance to copper sulfate. The strains isolated from cherry trees in selected orchards exhibited varying levels of tolerance to copper ions added to CYE medium in the vitro test (Table 3).

   Bacterial strains that were able to grow at 0.25 mM $CuSO_4$ in the medium were considered resistant to copper sulfate. Of the 110 *Pseudomonas syringae* strains tested, 82% (90 strains) were tolerant to copper at 0.25 mM $CuSO_4$ in the medium. Copper resistant strains of *P. syringae* were found in seven orchards. The strains from orchards 7 and 9 were sensitive to copper, but only a few from those orchards were tested for copper sensitivity. All strains tested from orchards 3, 4, 5, 6, and 8 were resistant to copper sulfate at 0.25 mM $CuSO_4$ in the medium while 26% and 83% of strains tested from orchards 1 and 2, respectively, were resistant. Among the strains resistant to copper, 39% of the bacterial strains also were resistant to 0.5 mM $CuSO_4$. Strains from orchards 1 and 2 were also resistant to copper sulfate at 1 mM $CuSO_4$ in the medium, indicating highly resistant populations of the pathogen in these orchards, but these strains were at a low frequency of 4% and 11% for orchard 1 and orchard 2, respectively.

Table 3. Resistance to copper sulfate of *Pseudomonas syringae* strains collected from sweet cherry orchards in Washington State from 2000 to 2001.

Orchard	Number of strains tested	% of strains growing				
		Copper sulfate in CYE medium (mM)				
		0	0.25	0.5	1	2
1	23	100	26	26	4	0
2	18	100	83	78	11	0
3	14	100	100	93	0	0
4	15	100	100	0	0	0
5	4	100	100	50	0	0
6	15	100	100	100	0	0
7	2	100	0	0	0	0
8	15	100	100	0	0	0
9	4	100	0	0	0	0

3. The chemical control trial was conducted in a 2-year-old Lapins block in a commercial orchard in Omak. This block was adjacent to a 7-year-old Lapins block with severe bacterial canker. However, in our test block no canker lesion developed in the spring, and the grower also trimmed old canker tissues from the tree. Thus, no disease rating data was generated from this trial.

In summary, bacterial canker occurs with relatively low incidence in the Yakima and Wenatchee area. The disease was more noticeable in the northern fruit production region from Pateros to Oroville. Young trees were particularly prone to infection by *Pseudomonas syringae*. The strains of *Pseudomonas syringae* isolated from cherry orchards exhibited varying levels of tolerance to copper in the in vitro test.

Information on the occurrence of the disease was from large field surveys from which cherry blocks were randomly selected. Although the survey indicates a relatively low incidence of bacterial canker, we have also been invited to some young commercial cherry blocks at some specific sites and have seen severe epidemics of bacterial canker in the blocks, particularly on varieties Lapins and Sweetheart. As the acreage of new plantings increases, bacterial canker can be an important factor in the process of establishing profitable young orchards. Dr. Gary Grove and I will keep eyes on this disease.

Acknowledgment:
We thank Dana Faubion, Herb Teas, Lee Gale, Wally Penhallegon, Jeff Hallman, Steve Harris and Maurice Sawyer for their assistance during the orchard survey; Steve Harris for cooperation in the chemical control trial; and Aude Pelletan and Debbie Corey for their technical support. We also thank the Washington Tree Fruit Research Commission for the financial support.

FINAL REPORT

Managing Lab and Field Populations of Cherry Fruit Fly - Final Report
Funding in 2001-02, $24,000

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The objectives of the project in 2001-2002 were to:
1. Develop a laboratory source of larval and adult flies available throughout the year for biological studies.
2. Manage a cherry orchard at the ARS Moxee Farm specifically to establish a population of cherry fruit flies for use in field studies.
3. Initiate trapping studies to determine degree day phenology of flies, to test attractants, to conduct behavioral studies and to determine dispersal distances.

Prior to 2001, work was already underway to establish a western cherry fruit fly colony to provide flies for research. In 2000, traps collected flies at Moxee for the first time. These presumably originated from infested fruit brought in from other areas. A transect indicated that some cherries from all trees were infested. Of 240 fruit collected (10 per tree), 103 pupae were collected. In the laboratory, over 1,600 field-collected flies were used in quarantine treatment studies, and 60 flies in attractant research. In addition, over 50% of eggs laid on artificial wax domes ultimately became pupae, which was the highest conversion rate achieved.

Results
Objectives 1, 2, and 3 were met during 2001, as follows.

Objective 1.
A laboratory colony of flies was successfully established at the Yakima Agricultural Research Laboratory. This colony allowed experiments to be conducted during fall, winter, and spring, periods when the flies are absent in the field. The colony originated from extensive field collecting of infested fruit from > 200 trees in Yakima, Benton, Chelan, Douglas, and Kittitas Counties. Larvae dropped from fruit into soil held in tubs, where they pupated. After 1-2 weeks at room temperature, pupae were transferred to a cold room held at 3 °C for 4-7 months. Emerged flies were allowed to lay eggs into fruit in the laboratory. The larvae and pupae were obtained, and then pupae were to adults in order to perpetuate the colony. Flies also were allowed to lay eggs onto artificial wax domes. Larvae were then placed in artificial diet, and then reared to adults. Rearing on cherries obtained from Chile and stored during the winter resulted in higher production of flies and will be the preferred rearing method in the future, whereas use of artificial diet (AliNiazee and Brown 1977) will serve as a backup method. Procedures for maintaining flies in the cold during diapause also were developed. Flies were found to emerge over a wide range of time, in agreement with previous studies (Van Kirk and AliNiazee 1981, Stark and AliNiazee 1982). Emergence of flies reached 80% in many cases. In some, only 20-30% emerged, and studies are planned to determine why emergence was low in these cases. Although some of the flies that emerged in the laboratory were used to perpetuate the colony, the majority were used in detailed biological studies, including a study on the effects of different sugar concentrations and cherry, sugar and yeast diets on fly feeding duration, longevity and

fecundity. This study is near completion and data are summarized in Tables 1, 2, and 3. In addition to this study, a mating study (Table 4) and several studies on the effects of nematode (Tables 5 and 6) and *Bacillus thuringiensis* exotoxin on fly mortality were conducted using flies from the established colony. Thus the establishment of the colony was invaluable in providing flies needed in many studies that will help in understanding fly biology and ultimately in fly management in cherry orchards.

Objective 2.
The cherry orchard at the Moxee Farm was successfully infested. Fruit collected in 2000 were infested with maggots, as they were in 2001. Visual inspection of trees confirmed fly presence and that flies were attacking the cherries. The flies in this orchard were used to initiate field studies (below).

Objective 3.
Temperature and humidity data were gathered from July through mid August. This allowed degree-day models (AliNiazee 1976, 1979) to be used in predicting fruit fly emergence. Because of its relatively high altitude, flies at Moxee emerged 1-2 weeks later than the surrounding areas (Tri-Cities, Zillah, and Yakima). One hundred yellow sticky traps were hung on trees during July to confirm infestation. A total of 428 flies was collected on ammonia-baited traps between 10-24 July, confirming high infestation. Numbers caught in these traps on 9 days (at 2 or 3 day intervals) were 176, 145, 22, 27, 13, 15, 12, 3, and 4. Because the orchard was isolated, it was unlikely these flies originated from outside the orchard. These data provided information on seasonal activity of resident flies at the orchard, and they should prove valuable in planning future work at this site. Approximately 200 flies from the orchard were also collected for a dispersal study, marked, released, and re-sighted or re-captured. Dispersal distances of flies in the presence and absence of high fruit loads in this study were determined (Table 7).

Discussion
The establishment of laboratory and maintenance of field populations of the western cherry fruit fly proved indispensable for research. We tested and modified techniques published before on cherry fruit fly colonization (AliNiazee and Brown 1977). Without the laboratory colony, research progress would have been slowed considerably, and would have been impossible during the winter. Research would have been possible only from May to August, when the fly is active in the field. Without the field population at Moxee, field research would have been and potentially will be greatly hindered. Although the research can still proceed because of homeowners who cooperate and allow us use of their infested trees, this cannot be considered a reliable resource in the future, whereas the Moxee orchard can be a reliable resource indefinitely. Because much of the research in fly management begins with preliminary, controlled laboratory studies or experiments, there remains a continual need for a laboratory colony of the western cherry fruit fly.

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Tables 1-7: Studies resulting from establishment of laboratory and maintenance of field populations of western cherry fruit fly, *Rhagoletis indifferens*

Table 1. Mean feeding duration (min) and longevity (d) ± SE of female and male *Rhagoletis indifferens* fed single meals of cherry juice, sucrose of different concentrations, and dry sugar-yeast diet 1-2 days after emergence.

	Females			Males		
Treatment	*N*	Feeding Duration Longevity min± SE	Longevity days ± SE	*N*	Feeding Duration min ± SE	days ± SE
Cherry Juice	7	7.80 ± 1.83	4.4 ± 0.2	3	3.04 ± 0.64	4.0 ± 0.0
No Food (water)	22	0.32 ± 0.08	4.0 ± 0.1	19	0.31 ± 0.10	4.3 ± 0.2
Sucrose (Wet Food)						
2%	6	1.08 ± 0.34	4.2 ± 0.3	6	1.90 ± 0.44	3.8 ± 0.5
10%	9	2.19 ± 3.05	4.6 ± 0.2	8	2.21 ± 0.41	4.0 ± 0.2
20%	9	4.25 ± 1.28	4.7 ± 0.3	8	3.34 ± 1.14	4.2 ± 0.3
40%	10	2.96 ± 0.17	6.1 ± 0.1	8	2.53 ± 0.39	5.5 ± 0.3
60%	11	4.56 ± 0.69	6.7 ± 0.3	9	4.38 ± 0.57	6.8 ± 0.2
80%	9	15.20 ± 1.72	7.2 ± 0.5	5	10.02 ± 1.90	6.5 ± 0.3
Sucrose (80%)-Yeast (20%) Food	4	129.37 ± 39.67	5.2 ± 0.5	------	-------	------

Table 2. Mean longevity and fecundity of female *Rhagoletis indifferens* exposed to sweet cherry and sugar and yeast dry and wet diets in the laboratory.

Treatment[a,b]	*N*	Longevity (d) Per Female + SE	No. Total Eggs Per Female + SE	% Eggs of Best Diet
Test 2 - 1 female and 1 male/cage				
(All with Cherries)				
1- Cherry only from start	11	37.6 ± 5.9a	86.1 ± 21.3a	24.2
2- + 88-12 throughout	9	63.1 ± 6.7b	356.2 ± 53.9b	-------
3- + 88-12 for 14 d	7	36.6 ± 6.1a	157.0 ± 55.4ab	44.1
4- + 47-6 throughout	3	49.0 ± 6.6ab	267.3 ± 60.0ab	75.0
5- + 47-6 for 14 d	4	31.0 ± 5.6a	135.5 ± 76.6ab	38.0
Test 3 - 3 females and 3 males/cage				
(All with Cherries except 4)				
1- + 80-20 throughout	7	60.6 ± 6.6 a	325.8 ± 62.2a	-------
2- + 80-20 for 14 d	10	34.0 ± 3.2b	133.0 ± 27.5b	40.8
3- + 80-20 for 8 d	7	35.3 ± 3.1b	171.3 ± 26.4ab	52.6
4-No cherry, 80-20 for 8 d only	6	10.1 ± 0.6c	0 ± 0c	0

[a]88-12: 88% sucrose and 12% yeast, dry diet. 47-6: 47% sucrose and 6% yeast, wet diet; 80-20: 80% sucrose and 20% yeast, dry diet.
[b]Except for test 1, treatment 1 and test 3, treatment 4, cherries in treatments were introduced on day 8. Means followed by the same letter within columns are not significantly different ($P > 0.05$).

Table 3. Effects of cherries and male and female presence on longevity and fecundity of *Rhagoletis indifferens*.

Treatment	*N*	Longevity (d) ± SE Males	Longevity (d) ± SE Females	No. Total Eggs per Female ± SE
(1) 6 males only + C	2	23.8 ± 3.8	-------	-------
(2) 6 females only + C	2	-------	46.5 ± 0.7	107.7 ± 11.9
(3) 3 males + 3 females + C	3	48.8 ± 1.9	41.9 ± 5.3	128.2 ± 12.1
(4) 6 males only + S	__	_____	-------	-------
(5) 6 females only + S	__	-------	_____	_____
(6) 3 males + 3 females + S	__	_____	_____	_____
(7) 3 males + 3 females No Food	3	3.5 ± 0.2	4.1 ± 0.1	0 ± 0

C = Cherry; S = Dry Sucrose Cubes.

Table 4. Mean number of matings/day and mean duration of matings (minutes) of *Rhagoletis indifferens* under laboratory conditions.

Treatment Ages (days) Male	Females	*N*	% of Pairs Mated	Mean No. Matings/Day ± SE	Mean Mating Duration ± SE	Matings
3-6	3-6	12	16.7	0.06 ±0.04	5.64 ± 5.36	2
3-6	17-26	10	40.0	0.30 ± 0.15	72.51 ± 25.05	4
17-26	3-6	9	22.2	0.26 ±0.19	61.56 ± 7.36	2
17-26	17-26	24	29.2	0.57 ± 0.37	31.39 ± 13.58	6
32-67	32-67	11	72.7	0.33 ± 0.11	10.02 ± 5.33	8

Table 5. Mean percent mortality ± SE and % pupation (in parentheses) of *Rhagoletis indifferens* larvae exposed to two concentrations of infective juveniles (IJ) in a soil mixture with 20% moisture at 27 °C.

			Test 1 (21 days after exposure)	
Concentration	*N*	Control	*Steinernema feltiae*	*Steinernema carpocapsae*
0	5	52 ± 5 (60 + 7)	-------	-------
500,000 IJ/m^2	5	-------	100 ± 0 (40 ± 4)	100 ± 0 (54 ± 5)
1,000,000 IJ/m^2	5	-------	100 ± 0 (30 ± 9)	100 ± 0 (48 ± 8)

			Test 2 (20 days after exposure)		
Concentration	*N*	Control	*Steinernema feltiae*	*Steinernema carpocapsae*	*Steinernema intermedium*
0	5	6 ± 4 (94 ± 4)	-------	-------	-------
500,000 IJ/m^2	5	-------	100 ± 0 (56 ± 11)	100 ± 0 (54 ± 10)	66 ± 12 (64 ± 8)
1,000,000 IJ/m^2	5	-------	100 ± 0 (58 ± 6)	100 ± 0 (58 ± 9)	54 ± 12 (56 ± 9)

			Test 3 (12 days after exposure)		
Concentration	*N*	Control	*Steinernema feltiae*	*Steinernema carpocapsae*	*Steinernema intermedium*
0	5	22 ± 10 (78 ± 10)	-------	-------	-------
500,000 IJ/m^2	5	-------	100 ± 0 (28 ± 8)	100 ± 0 (26 ± 12)	96 ± 4 (20 ± 8)
1,000,000 IJ/m^2	5	-------	100 ± 0 (20 ± 8)	100 ± 0 (26 ± 7)	92 ± 8 (20 ± 7)

Table 6. Mean percent mortality and % pupated (in parentheses) ± SE of *Rhagoletis indifferens* larvae exposed to water and placed directly into soil and exposed to 500,000 infective juveniles (IJ) in a soil mixture with 20% moisture at 27 °C after 7 days.

Treatment	*N*	In water for 24 hours	Directly in soil
Control	3	0 ± 0 (100 ± 0)	0 ± 0 (100 ± 0)
Steinernema feltiae	3	100 ± 0 (67 ± 9)	100 ± 0 (20 ± 20)
Steinernema carpocapsae	3	100 ± 0 (50 ± 6)	100 ± 0 (7 ± 3)

Table 7. Numbers of marked and released *Rhagoletis indifferens* sighted in 2-min/tree searches on 119 trees and collected from 100 trees, % seen or recaptured, and mean distances (m) ± SE seen from release trees at 1-23 days after release (DAR) in 2001 at Moxee, WA.

		Numbers of Marked Flies Sighted (all males)					
Date	DAR	Control	%	Mean Distance/Fly	Treatment	%	Mean Distance/Fly
3 July	1	12	2.2	34 ± 7	9	1.2	32 ± 8
5	3	6	1.1	55 ± 12	5	0.6	56 ± 10
9	7	2	0.4	48 ± 22	1	0.1	42
Totals seen		20	3.6	--------	15	1.9	--------

		Numbers of Marked Flies Collected on Yellow Traps (all males, 1 female 10 July)					
Date	DAR	Control	%	Mean Distance/Fly	Treatment	%	Mean Distance/Fly
10 July	10	13	2.3	49 ± 5	5	0.6	24 ± 4
12	11	10	1.8	34 ± 5	10	1.3	52 ± 9
13	12	1	0.2	87	1	0.1	79
16	15	0	0	-----	0	0	-----
18	17	2	0.4	38 ± 24	0	0	-----
20	19	3	0.5	54 ± 15	0	0	-----
23	22	0	0	-----	1	0.1	31
25	24	0	0	-----	-----	-----	-----
27	26	0	0	-----	-----	-----	-----
Totals		29	5.2	43 ± 4	17	2.2	44 ± 6

CONTINUING PROJECT **YEAR 2**

WTFRC Project # Ch-01-12, continuing

Project title: Isolation of Mating Pheromone in Cherry Fruit Fly

PI: Wee. L. Yee, Research Entomologist

Organization: USDA-ARS, Wapato, WA
Co-PIs and affiliation: Pete J. Landolt, Research Entomologist, ARS, Wapato, WA

Objectives: Objectives in 2001 were to 1) document and describe mating behaviors of the western cherry fruit fly in the laboratory, to 2) determine the effects of age on mating success and fecundity, and to 3) document mating behaviors of flies in the field. The objectives for 2002-2003 are to 1) demonstrate the presence of a mating pheromone in the fly using laboratory wind tunnel and field bioassays, to 2) compare the ability of laboratory- and field-collected males to attract females, and to 3) characterize the chemicals responsible for attraction of females to males. The 2001 study described the behaviors involved in mating and ultimately can be used as a basis for evaluating the quality of male flies that are sterilized for use in the sterile insect technique. However, chemical cues may be equally important in mating in many fruit fly species (e.g., Feron 1959, Nation 1972, Prokopy 1975). The European cherry fruit fly, a close relative of the western cherry fruit fly, also uses sex attractants (Katsoyannos 1976, 1982). Pheromones may eventually prove to be valuable in the arsenal of control tactics against the cherry fruit fly. Using a sex attractant to trap and kill female flies may help reduce the sole reliance on cover sprays that may be harmful to the environment. First, however, the existence of the pheromone needs to be established, and second, it needs to be isolated and its chemical nature and characteristics need to be determined.

Significant findings:
- Western cherry fruit flies mated on average for 5-73 min, with the longest duration in 17-26 day old flies. In the lab, males jumped on females from behind, the front, or side to initiate mating. There was no true courtship behavior.
- Flies that were 3-6 days old mated less than older flies.
- Flies > 32 days old showed the highest frequency (73%) of mating.
- Male flies in the field gathered on fruit to wait for females to arrive to mate, and protected their fruit territories by fighting off other males.
- Flies in the field initiated mating on fruit, but fell off fruit to complete mating.

Methods:
1. Wind tunnels based on a design described by Katsoyannos et al. (1980) for testing responses to pheromone by the European cherry fruit fly will be constructed. The wind tunnel consists of a plexiglass cage and a series of funnels. The tunnel consists of three main elements: a test cage (15 inches long × 12 inches wide × 12 inches high), a tube system (24 inches long), and a ventilator. The test cage holds the virgin female flies. The tube system consists of a capture chamber and a bait cage that holds the male flies. The ventilator is a fan that blows air through the system. The fan picks the odor of the male bait cage and carries it to the female test cage. Females that are attracted to the odor fly upwind and are trapped in the catch chamber. Twenty-30 virgin females that are 10 days old will be placed in the test cage and 30-50 males in the bait cage. Each assay will be conducted for 30 minutes. There will be a minimum of 15 replicates for treatments and controls (unbaited cages). Experimental conditions (temperature, relative humidity, photoperiod, and light intensity) for standard sex pheromone bioassays will follow

those listed in Katsoyannos et al. (1980). Percent of females responding to male-baited cages will be compared with the percent responding to unbaited cages. Preliminary tests will be run to determine the rhythmicity (time of day) of pheromone release and expected response. In *R. cerasi*, maximum female response occurs in the field around noon (Katsoyannos 1982). The same groups of flies will be tested on an hourly basis throughout the light cycle in preliminary tests.

A field test will also be conducted. Fifty males will be placed in a bait cage in a cherry tree and the numbers of females attracted to the cage compared with numbers attracted to an adjacent unbaited cage. At least 5 replicates will be conducted. Methods similar to those described by Katsoyannos (1976) will be used.

2. Laboratory-reared and field-collected females and males will be tested and compared using the wind tunnel.

3. Isolation of the pheromone will be conducted following methods described in detail by Chuman et al. (1987) and Heath et al. (1991) for papaya and Mediterranean fruit flies, respectively. Prefiltered air passed over 50 males in glass jars will be trapped using a Porapak N filter. The Porapak N filter will be washed with hexane. The crude pheromone will be concentrated to a small volume and subjected to gas-liquid chromatography (GLC). The GLC fraction that contains the major peak will be identified, removed, and tested for biological activity in a wind tunnel. At least 10 replicates of bioassays will be conducted. A mass spectrometer will be used to characterize the structures of principal chemical components in the active fractions

Results and Discussion:

Sixty-six pairs of flies of various age groups were video recorded over 16 hours for 3 consecutive days in 2001. Male flies mated with females by jumping on them behind, the side, or the front. No true courtship was observed. Few of the males were rejected by females. Although a cherry was placed in the cages, mating under laboratory conditions took place off the fruit. Mating occurred for an average of 5-73 min. During copulation, females sometimes walked around, but mostly remained still. The average duration of mating in the different age categories is shown in Table 1. Lowest mating frequency occurred in the youngest age groups, and the highest frequency of matings occurred in the oldest age groups. Older flies laid more eggs, but data are not complete.

Table 1. Mean number of matings/day and mean duration of matings (minutes) of *Rhagoletis indifferens* under laboratory conditions.

Ages (days)		% of Pairs	Mean No.	Mean Mating		
Male	Females	*N*	Mated	Matings/Day ± SE	Duration ± SE	No. Matings
3-7	3-6	12	16.7	0.06 ± 0.04	5.64 ± 5.36	2
3-7	17-26	10	40.0	0.30 ± 0.15	72.51 ± 25.05	4
17-27	3-6	9	22.2	0.26 ± 0.19	61.56 ± 7.36	2
17-27	17-26	24	29.2	0.57 ± 0.37	31.39 ± 13.58	6
32-67	32-67	11	72.7	0.33 ± 0.11	10.02 ±5.33	8

In the laboratory at constant temperature, mating occurred mostly in the evening (Fig. 1). In the field, where there were strong fluctuations in temperatures, mating was seen throughout the day, on both fruit and leaves (Fig. 2). It appears that mating times reflect general fly movement, and that mating occurs any time during the day whenever temperatures are 20-36 °C.

The mating behaviors of sterilized flies or flies altered in other ways need to be evaluated against normal flies. No evident characteristic distinguished rejected males from accepted males. However, because of the nature of the mating system, which involves males forcibly jumping on females and mating, it appears weaker, less aggressive males have a disadvantage. Thus any manipulations of males should not reduce their aggressiveness. It appears that mating occurs in flies of a wide age range, and this increases the feasibility of using sterilized males.

Mating behaviors and a sex attractant are intimately linked because females are drawn into the males' area before mating. A mating pheromone will help increase the numbers of ways flies can be managed. By attracting flies to traps with pheromone, females may be selectively removed from the population, and this will play a part in reducing pesticide use in the cherry system.

Budget:
Isolation of Mating Pheromone in Cherry Fruit Fly
Wee. L. Yee
Project duration: 2001-2003
Current year: 2002
Original budget request:

Year	Year 1 (2001)	Year 2 (2002)	Year 3 (2003)
Total	22,000	17,500	13,500

Current year breakdown

Item	Year 1 (2001)	**Year 2 (2002)**	Year 3 (2003)
Salaries and Benefits	15,000[1]	**17,500[4]**	12,000[6]
Goods and Services[2]	6,000	**1,500[5]**	1,500[5]
Travel[3]	1,000	**0**	0
Total	22,000	**19,000**	13,500

[1]One summer employee
[2] Materials for cage and video equipment
[3]Travel to field sites, fuel costs
[4]One GS-5 chemist ($16,500, full time, $11.32/h, 9 months)
One GS-5 technician ($1,000) for rearing flies
[5]Equipment to build wind tunnels, chemicals need to run bioassays and chemical characterization
[6]One GS-5 chemist ($11,000, full time, 11.32/h, 6 months)
One GS-5 technician ($1,000) for rearing flies

There is no support from other funding sources.

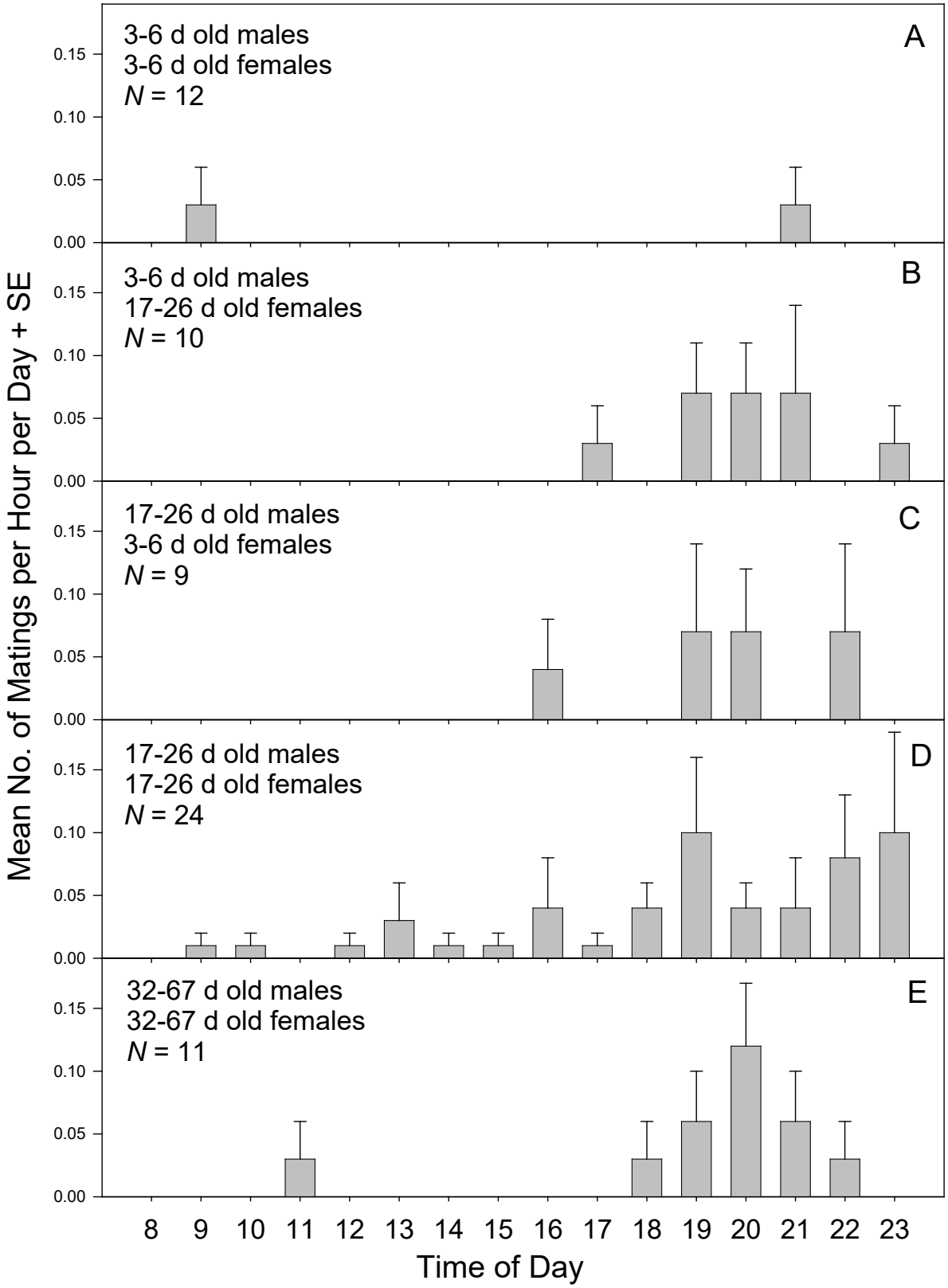

Fig. 1. Mating activity of flies of different ages in the laboratory.

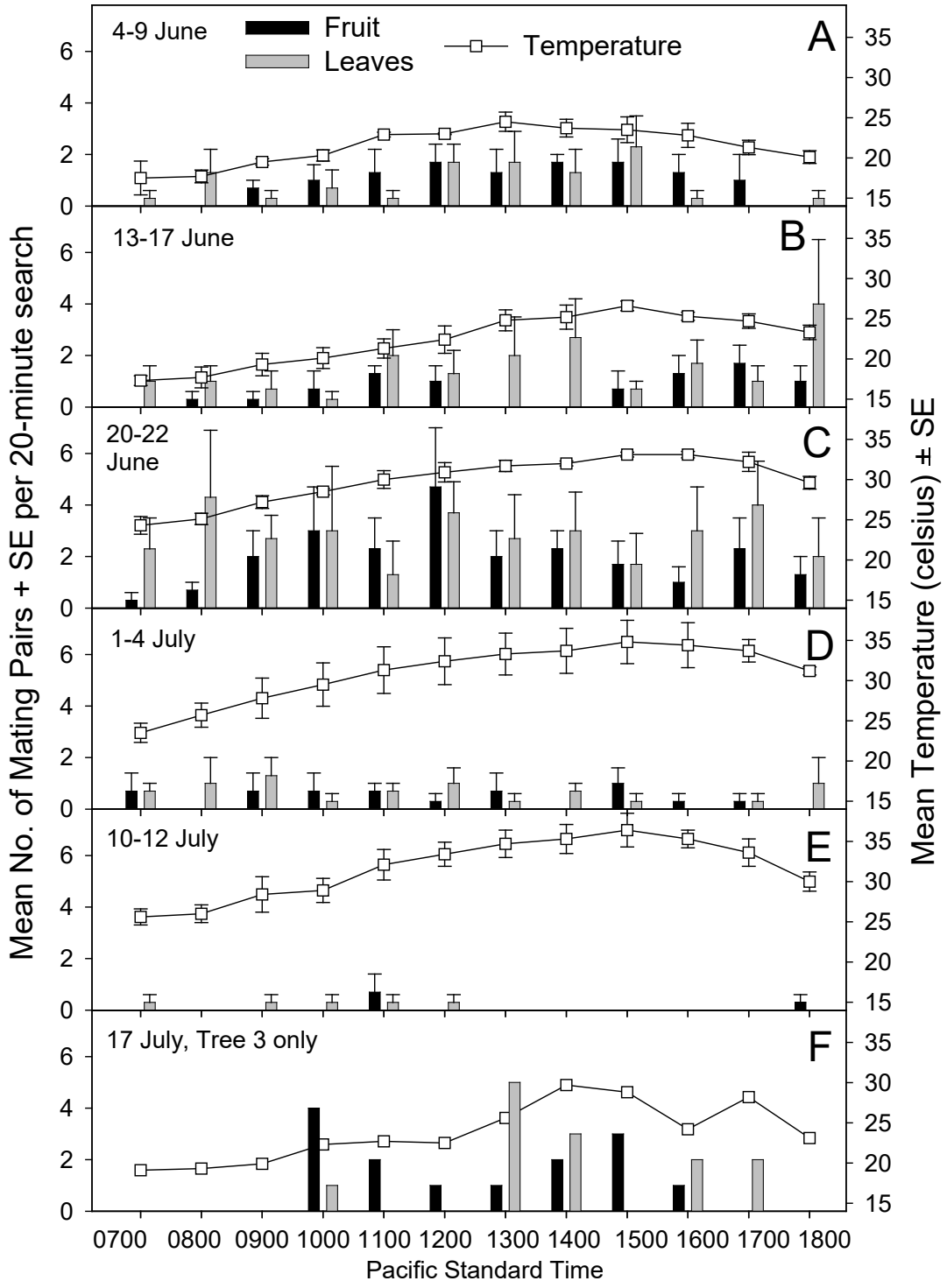

Fig. 2, page 5. Mating activity of flies in the field, June to July 2001, Yakima County, WA.

Literature review:

Chuman, T., P. J. Landolt, R. R. Heath, and J. H. Tumlinson. 1987. Isolation, identification, and synthesis of male-produced sex pheromone of papaya fruit fly, *Toxotrypana curvicauda* Gerstaecker (Diptera: Tephritidae). J. Chem. Ecology. 13: 1979-1992.

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Nation, J. L. 1972. Courtship behavior and evidence for a sex attractant in the male Caribbean fruit fly, *Anastrepha suspensa*. Ann. Entomol. Soc. Am. 65:1364-1367.

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CONTINUING PROJECT **YEAR 2**

WTFRC Project # Ch-01-13, continuing

Project title: Host Preference of Cherry Fruit Fly in Eastern and Western Washington

PI: Wee L. Yee, Research Entomologist

Organization: USDA-ARS, Wapato, WA

Objectives: Objectives for 2001 were to 1) determine western cherry fruit fly activity within days and during the season, to 2) relate fly abundance to larval infestation of fruit and to 3) determine distances flown by the flies. Objectives for 2002 are as follows: 1) determine host use patterns by western cherry fruit flies in eastern and western Washington; 2) determine preference of cherry fruit flies for different varieties of sweet and sour cherries and native hosts in the laboratory; and 3) determine developmental rates of flies in these different hosts. Practically nothing is known about western cherry fruit fly preference for different sweet and sour cherry cultivars and native cherry species.

Significant findings:

- Male western cherry fruit flies were found mostly on fruit, and their sightings outnumbered those of females by 8:2.
- Female flies were seen equally on leaves and fruit.
- Activity of flies is affected by time of day and temperatures; peak abundance occurred during the afternoon at temperatures of 24-35 °C; activity decreased significantly at <20 and >36 °C.
- Relationship between fly captures on yellow traps and larval infestation of fruit was generally weak, suggesting more effective traps are needed.
- Flies disperse an average of 30-60 m in the absence or presence of fruit on trees, suggesting dispersal is not necessarily dependent on fruit availability.

Methods:

1. Field studies will begin in early May and will be conducted in eastern and western Washington. In eastern Washington, study trees will be in Yakima and Benton Counties. In western Washington, study trees will be in Clark County and Skamania Counties. The types and amount of native hosts in these areas differ considerably (western Washington has a more suitable climate for bitter cherries). Baited yellow traps will be placed in popular and common sweet cherry varieties - 'Bings', 'Rainiers', 'Lapins', 'Royal Anns', 'Sweethearts', and others if available, and in sour cherries - 'Montmorencys', and others, as well as native bitter cherries and chokecherries, throughout the sampling areas. Also, non-cherry hosts such as black hawthorn and cascara, which have fruit that resemble cherries, will be included in the study. At least 10 trees of each host will be trapped. Efforts will be made to trap trees that are close together to facilitate comparisons. Timed observations (20 min/tree) of fly activities and behaviors - especially oviposition, but also mating, feeding, and resting - and visual counts will be made on the different hosts at least twice a week throughout the season. Records will be made of the development of fruit stages, the time of fruit drop, time of removal by birds, and related to fly captures and counts throughout the season.
2. Fruit soon after maturity from the different hosts will be randomly collected and checked for infestation (oviposition punctures and larval exit holes) under a microscope. Infested fruit will be discarded. Commercial or residential (treated or uninfested) fruit will also be obtained, washed, and used in experiments. Sweet and sour cherries of different varieties will be presented to single flies in choice and no choice tests. Flies will be laboratory-reared or field-collected. In the latter,

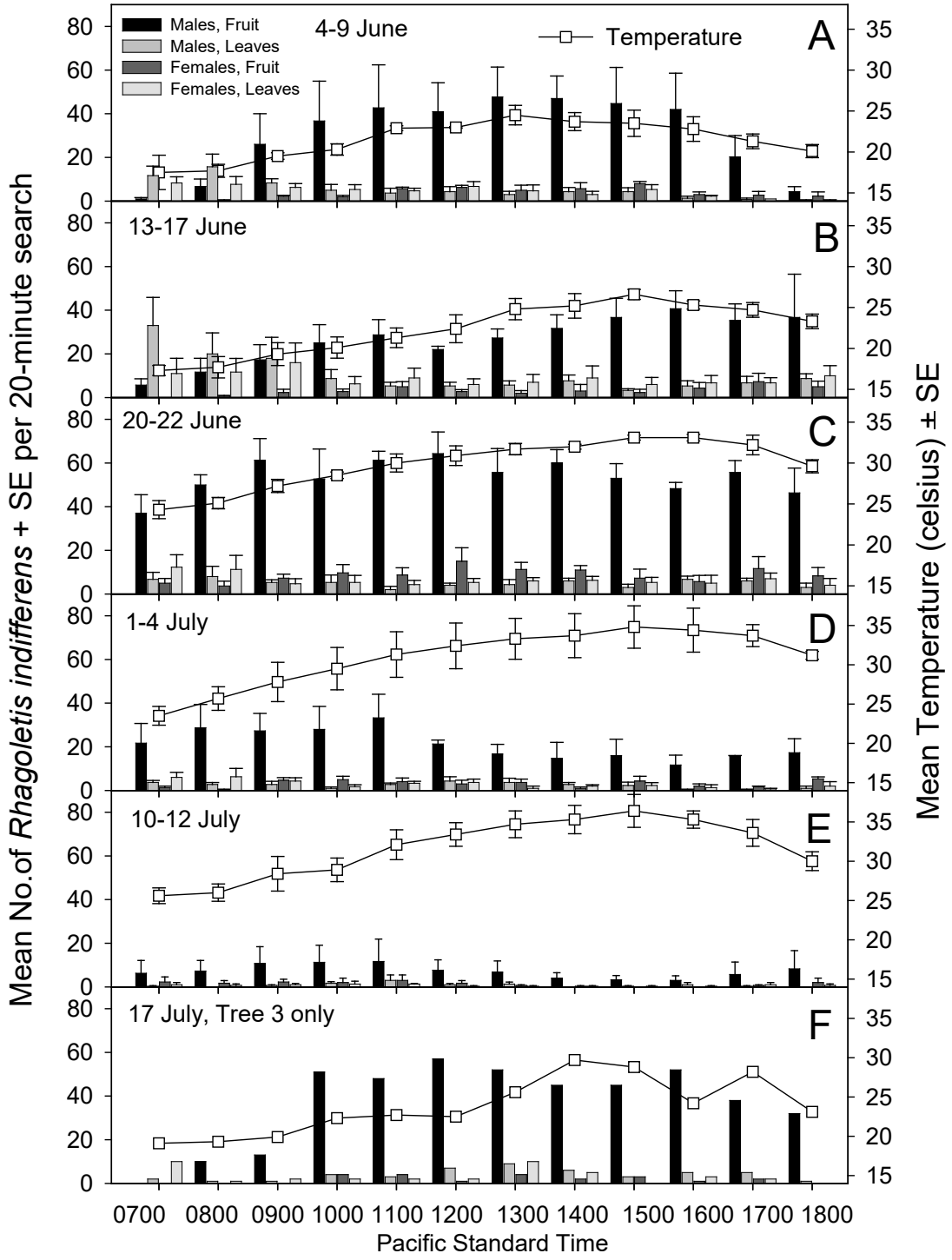
flies collected from different hosts will be exposed to different fruit to determine if fly origin or prior experience on a host affects host preference. At least 20 replicates of each treatment will be conducted. For eastern Washington studies, the behaviors of the flies will be tracked using a video monitoring system (Ethovision) to determine times spent by flies on hosts and whether flies are rejecting hosts. Fruit will be exposed to flies for 24 h.

3. Larvae will be allowed to develop in hosts. Fruit will be placed in containers and held at a constant 27 °C. Containers will be checked daily for emergence of larvae. Development times and survival rates will be determined.

Results and Discussion:

The diurnal activity patterns of the fly were determined on three sweet cherry trees from 0700-1800 hours from June through July 2001 in Yakima County, WA (Fig. 1). Temperatures during the season and day had a strong impact on fly sightings. When temperatures were < 20 °C at 0700 hours in early June, flies of both sexes were seen mostly on leaves, but when they reached 20 °C, most male and more female flies moved onto fruit. Sightings were greatest when temperatures were 24-35 °C. When temperatures were 36-41 °C, most flies vanished from view and those seen were less active. Over the entire season, males were seen more often on fruit (85.3%) than on leaves (14.7%), and spent significantly longer periods on fruit than on leaves, whereas females were seen on fruit (50.5%) and leaves (49.5%) equally, spending about equal time on both when temperatures were 20 to 36 °C. Males (80.2%) were sighted 4 times more often than were females (19.8%) over the season. Mating (seen in progress) was seen more on leaves (56.6%) than on fruit (43.4%). On cooler days, most flies were seen on the warmer, sunny sides of trees, and movement of flies from the east to the west tree quadrants during the day was evident. On warmer days, there was less horizontal movement and flies were distributed more evenly among quadrants. Only 7.6% of females on fruit were seen probing or ovipositing and only 0.92% of all females was seen feeding on fruit juice and bird feces. The results show that fly activity and times spent on fruit and leaves are greatly altered by seasonal and diurnal changes in temperature. However, when temperatures were 20 to 36 °C, the relative abundance of sexes seen and the male and female tendencies to seek fruit or leaves were the same regardless of the time during the season and the time of day (Fig. 1).

Fig. 1 (following page). Activity of male and female cherry fruit flies in 3 cherry trees in Yakima County from June to July 2001.



Relationships between fly catches on traps and infestation levels were poor, even though 47 trees were included in the study. In most cases, there was not a strong relationship between trap catches and infestation of fruit. The one exception appeared to be with pie cherries; the relationship was positive, except for one outlying observation (Fig. 2). Infestations were generally <1 larva per fruit.

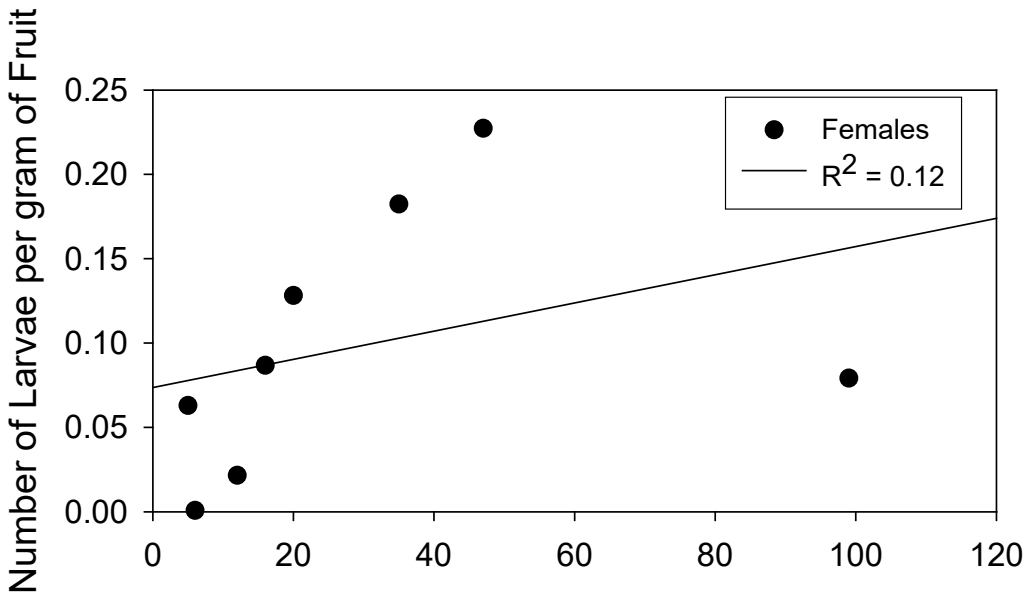


Fig. 2. Relationship between numbers of flies caught on yellow traps and larval infestation of sour cherry fruit.

The numbers of newly-emerged flies that were collected using emergence cages in the dispersal study were low. Therefore, mature flies were collected from trees throughout Yakima County. A total of 1,333 flies was collected, marked, and released. Fruit were removed from around the release point in one treatment and left on trees in the second treatment. The numbers of marked flies are shown in Table 1.

Table 1. Numbers of marked flies re-sighted (all males), % recovered, and mean distances recovered from release points in 2001 dispersal study.

Date	DAR	Control	%	Mean Distance/Fly	Treatment	%	Mean Distance/Fly
3 July	1	12	2.2	34 ± 7	9	1.2	32 ± 8
5	3	6	1.1	55 ± 12	5	0.6	56 ± 10
9	7	2	0.4	48 ± 22	1	0.1	42

Although there was no apparent effect of fruit presence early in the study, there was some evidence that lack of fruit affected the location of the flies later in the study. Of the 46 marked flies collected with sticky traps, 12 (26.1%) were captured within the two sets of nine core untreated trees, whereas only 2 (4.3%) were recaptured within the three sets of nine core treated trees. However, only 6.9% (N = 29) of control and 5.9% (N = 17) of treatment flies were recaptured within the core area of their release

Less than 3% of the released flies per treatment were re-sighted or collected on a given day, and all were males except for one. No differences in mean distances between flies released in control and treated trees were seen (Table 1).

The changes in daily and seasonal activity of flies indicate there are susceptible periods when flies can be more effectively controlled than in others. For example, it may be possible to develop soft chemicals to use on flies when they are least active, i.e., when temperatures are too low or high. Because fly movement is limited and flies are mostly on leaves at such times, much smaller amounts of relatively non-toxic, contact chemicals can have an effect.

A single, standard yellow trap baited with ammonia appears insufficient to evaluate the actual fly population that will lay eggs in fruit within a tree. Better, more attractive traps need to be designed, and methods other than using traps to predict infestation are needed. The fact that many flies disperse regardless of fruit load indicates the need to closely monitor and potentially treat all trees within 30-60 m in abandoned orchards or yards. Knowledge of host preference will affect control measures by allowing better decisions to be made on which cherry varieties to grow, which ones incur the highest control costs, and subsequently which ones to selectively target for fly control measures.

Budget:
Host Preference of Cherry Fruit Fly in Eastern and Western Washington
Wee L. Yee
Project duration: 2001-2003
Current year: 2002

Year	Year 1 (2001)	**Year 2 (2002)**	Year 3 (2003)
Total	14,000	**18,500**	18,500

Current year breakdown:

Item	Year 1 (2001)	**Year 2 (2002)**	Year 3 (2003)
Salaries and Benefits	11,000[1]	**16,000[4]**	16,000[4]
Goods and Services[2]	2,250	**1,000**	1,000
Travel[3]	750	**1,500**	1,500
Total	14,000	**18,500**	18,500

[1]One summer employee
[2] Materials for emergence traps, yellow sticky cards, spheres, paint, vials, camera supplies
[3]Travel to field sites, fuel costs
[4] Three summer employees:
GS-3-5 Technician (Yakima) $7,500 (full time, $9.02-$11.32/h, 4 months)
GS-4-5 Technician (Vancouver) $7,500 (full time, $11.32/h, 4 months)
GS-4-5 Technician (rearing) $1,000
There is no support from other funding sources.

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CONTINUING PROJECT **YEAR 2**

WTFRC Project # CH-01-10 continuing

Project title: Effects of Steinernematid Nematodes on Cherry Fruit Fly in the Field

PI: Wee L. Yee, Research Entomologists

Organization: USDA-ARS, Wapato, WA
Co-PI and affiliation: Lerry Lacey, Research Entomologist, USDA-ARS, Wapato, WA

Objectives: Objectives in 2001 were to 1) conduct efficacy studies of *Bacillus thuringiensis* (BT) beta-exotoxin against pre-pupal western cherry fruit fly larvae under laboratory and simulated field conditions and to 2) evaluate the potential of steinernematid nematodes for control of pupae and emerging adults of flies under laboratory and simulated field conditions. Objectives in 2002-2003 are to further evaluate the efficacy of nematodes in the field. Specifically, they are to 1) determine effects of *Steinernema carpocapsae* and *Steinernema feltiae* on mortality of larval flies in the field and the 2) effects of these nematodes on adult mortality in the field. Steinernematid nematodes have previously been shown in laboratory tests to be highly effective in killing larvae of the western cherry fruit fly (Patterson Stark and Lacey 1999). These tests showed that *S. carpocapsae* and *S. feltiae* caused 40-84% larval mortality on wet paper disks. Steinernematid nematodes also cause mortality of Caribbean fruit fly (Beavers and Calkins 1984) and Mediterranean fruit fly larvae (Lindegren and Vail 1986) in the laboratory. Because of the success in using nematodes to kill larvae in the laboratory, use of nematodes to manage flies in the field warrants consideration and needs to be investigated.

Significant findings:
•BT beta-exotoxin was highly toxic to adult western cherry fruit flies when ingested at 1% concentration in a sugar solution; 100% mortality occurred within 7 days.
•BT beta-exotoxin was not effective against larvae when exposed to them on paper disks, indicating this toxin needs to be ingested.
•*Steinernema carpocapsae* and *S .feltiae* consistently caused 100% mortality of larval flies when applied in soil in the laboratory.
•A third nematode species, *S. intermedium,* was less effective, but it still caused 54-100% larval mortality.
•Adult flies were much less susceptible to nematodes than the larvae.

Methods:

1. Effects of nematodes on fly larvae and pupae will be determined using 4 treatments and a control in field tests at the USDA farm in Moxee and in residential yards. Treatments will be the 2 species of nematodes at 2 concentrations. Concentrations of 500,000 and 1,000,000 infective juveniles per m^2 of soil will be applied once or twice between June and July. Applications to the ground beneath trees will be made with a backpack sprayer followed by thorough irrigation of the soil. Soil temperatures and moisture will be monitored. Two sources of fly larvae will be used at Moxee. Fruit gathered from infested trees in June and July will be brought into the laboratory and the larvae obtained from the fruit. At least 200 larvae will be spread over a 1 m^2 area of treated or untreated soil. In a second set of experiments, infested fruit will be placed directly onto the ground that have been treated or untreated. In both cases, pupae will be

removed from the soil, brought into the laboratory, and the percentage mortality determined. There will be at least 5 replicates for each treatment.

A third set of experiments will be conducted in three residential yards. Infestations on trees in mid June-July will be determined by examining ripe fruit for larvae. Under large (20-30 ft diameter) trees, the entire area will be divided into nematode-treated or control areas, each 1 m^2. Under smaller trees, one 1 m^2 area will be designated. Procedures similar to those in the first two sets of experiments will be followed. Depending on the ground characteristics (bare or grassy), pupae will be removed from soil and dissected to determine mortality or numbers of adults that emerge the following spring will be determined.

To determine the establishment or persistence of the nematodes in the ground, samples of soil from all tests will be removed pre-treatment and at 1, 2, 4, and 6 months post application and brought into the laboratory. Microscopic inspections will be made. In addition, *Galleria* wax moths, which are highly susceptible to nematodes, will be added to soil. Infection of moths will indicate persistence of nematodes in the soil.

2. Effects of nematodes on adults will be determined using the same treatments as with the larvae. Emergence cages will be placed over 1 m^2 treated and untreated areas underneath trees that were confirmed to be heavily infested in 2001. Numbers of emerged adults will be determined. Beginning at 3 days after application, the ground under cages will also be examined for dead adults. Adults will be placed in vials, returned to the laboratory, and examined for nematode infection.

Results and Discussion:

Adult flies that fed on BT beta-exotoxin did not survive past 6 days. In contrast, 60% of flies that fed on Agra-Quest, another organic material, were still alive at 6 days, and 40% of these flies survived up to 38 days. Flies that fed on sugar alone showed >75% survival throughout the 38-day experiment (Fig. 1). In contrast to the effects on adults, which ingested the toxin, larvae, which contacted the toxin only, were not affected. Mean survival of pupae after 29 days in the treated groups, at 74-86%, was comparable or higher than that in the control group, at 74%.

The results suggest that the exotoxin can be used as a substitute for other insecticides in bait traps, such as in pesticide-treated spheres treated with sugar bait and other attractants. In addition, small amounts of the material can possibly cause sublethal effects. Flies may not be killed, but may produce deformed and infertile eggs. A possible advantage of using the toxin over other insecticides (such as imidacloprid) is that only minute quantities need to be ingested.

When exposed to nematodes, large 3rd instar larvae in soil suffered 100% mortality (Tables 1 and 2). Adults, however, were less susceptible to nematodes, and few were infected (Table 3). The results suggest nematodes have potential as biological control agents of fly larvae. Factors that will influence their effectiveness in the field include their persistence in soil and their ability to find the larvae. Nematodes will likely need to be treated as biocides that require repeated applications to be effective. Longer-term survival of nematode populations, however, can be enhanced if suitable alternative hosts are present in the soil and if the soil is well maintained with adequate moisture. The behaviors of nematodes - whether they actively ambush hosts (*S. carpocapsae*) or passively wait for them (*S. feltiae*) - will also affect their effectiveness in managing fruit flies. These are factors that need to be studied before nematodes can be used on a large scale under infested trees.

Table 1. Mean percent mortality ± SE and % pupation (in parentheses) of cherry fruit fly larvae exposed to two concentrations of infective juveniles (IJ) in a soil mixture with 20% moisture at 27 °C.

			Test 1 (21 days after exposure)	
Concentration	*N*	Control	*Steinernema feltiae*	*Steinernema carpocapsae*
0	5	52 ± 5 (60 + 7)	-------	-------
500,000 IJ/m^2	5	-------	100 ± 0 (40 ± 4)	100 ± 0 (54 ± 5)
1,000,000 IJ/m^2	5	-------	100 ± 0 (30 ± 9)	100 ± 0 (48 ± 8)

			Test 2 (20 days after exposure)		
Concentration	*N*	Control	*Steinernema feltiae*	*Steinernema carpocapsae*	*Steinernema intermedium*
0	5	6 ± 4 (94 ± 4)	-------	-------	-------
500,000 IJ/m^2	5	-------	100 ± 0 (56 ± 11)	100 ± 0 (54 ± 10)	66 ± 12 (64 ± 8)
1,000,000 IJ/m^2	5	-------	100 ± 0 (58 ± 6)	100 ± 0 (58 ± 9)	54 ± 12 (56 ± 9)

			Test 3 (12 days after exposure)		
Concentration	*N*	Control	*Steinernema feltiae*	*Steinernema carpocapsae*	*Steinernema intermedium*
0	5	22 ± 10 (78 ± 10)	-------	-------	-------
500,000 IJ/m^2	5	-------	100 ± 0 (28 ± 8)	100 ± 0 (26 ± 12)	96 ± 4 (20 ± 8)
1,000,000 IJ/m^2	5	-------	100 ± 0 (20 ± 8)	100 ± 0 (26 ± 7)	92 ± 8 (20 ± 7)

Table 2. Mean percent mortality and % pupated (in parentheses) ± SE of cherry fruit fly larvae exposed to water and placed directly into soil and exposed to 500,000 infective juveniles (IJ) in a soil mixture with 20% moisture at 27 °C after 7 days.

Treatment	*N*	In water for 24 hours	Directly in soil
Control	3	0 ± 0 (100 ± 0)	0 ± 0 (100 ± 0)
Steinernema feltiae	3	100 ± 0 (67 ± 9)	100 ± 0 (20 ± 20)
Steinernema carpocapsae	3	100 ± 0 (50 ± 6)	100 ± 0 (7 ± 3)

Table 3. Mean percent ± SE of adult cherry fruit flies infected with nematodes exposed to 1,000,000 infective juveniles/m^2 in soil.

	Test 1			
Treatment	Mean no. 1st 3 days	% of adults with nematodes	Mean no. dead adults	% of dead adults with nematodes
Control	11.8	0	3.4	0
S. intermedium	13.6	0	6.2	0
S. feltiae	10.4	0	4.4	11.7 ± 7.3
S. carpocapsae	6.0	10.2 ± 5.0	9.0	9.6 ± 7.1

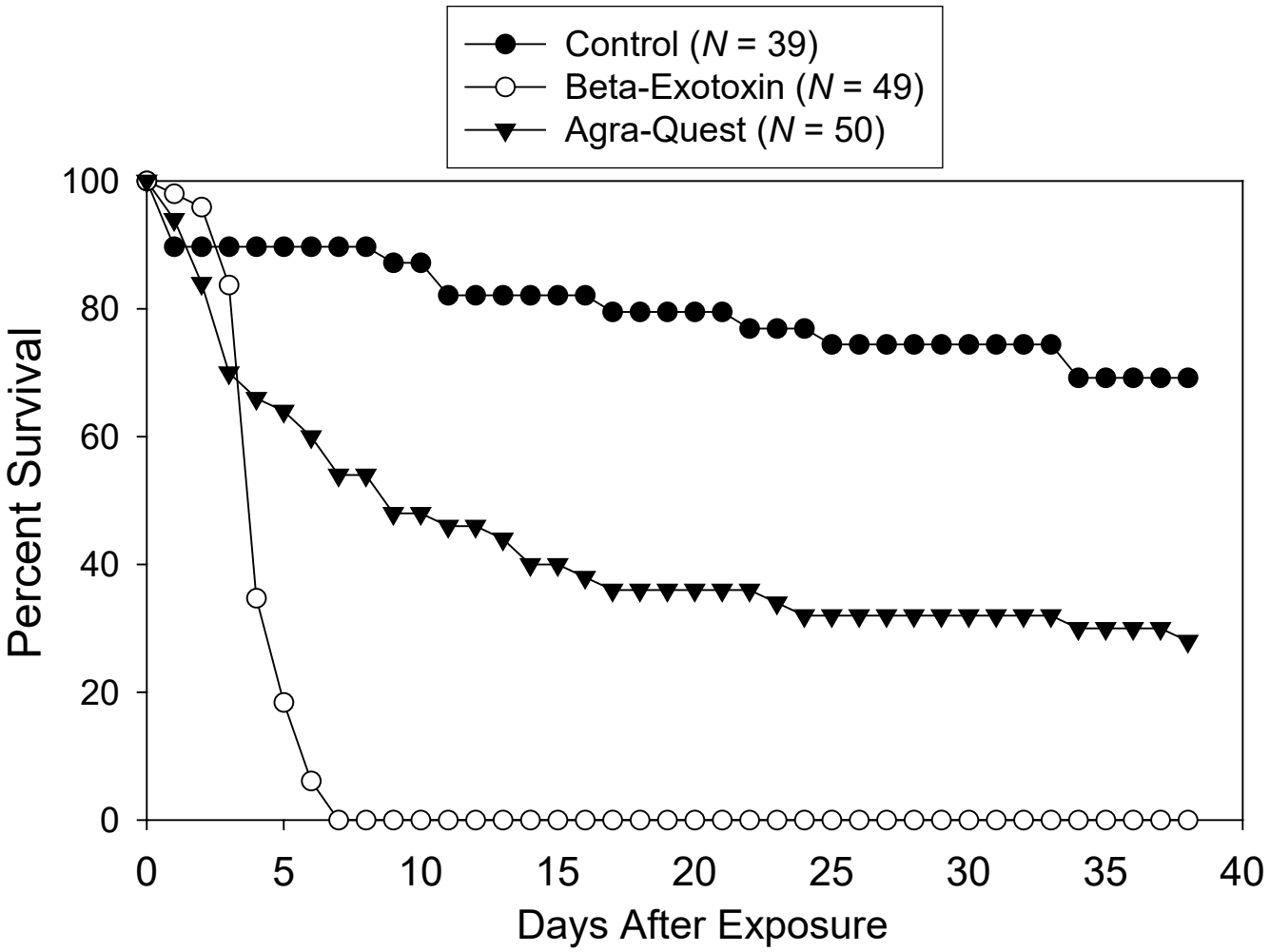


Fig. 1. Mortality of western cherry fruit fly adults exposed to BT beta-exotoxin and Agra-Quest as a function of days post-exposure.

Budget:
Effects of Steinernematid Nematodes on Cherry Fruit Fly in the Field
Wee L. Yee
Project duration: 2001-2003
Current year: 2002
Original budget request:

Year	Year 1 (2001)	**Year 2 (2002)**	Year 3 (2003)
Total	7,500	**13,000**	13,000

Current year breakdown:

Item	Year 1 (2001)	**Year 2 (2002)**	Year 3 (2003)
Salaries	7,000[1]	**11,500[4]**	11,000[4]
Goods and Services[2]	500	**500**	500
Travel[3]	0	**1,000**	1,000
Total	7,500	**13,000**	13,000

[1]One GS-3 summer employee
[2]Cages, general laboratory supplies
[3]To field sites, fuel costs
[4]One GS 3-5 employee ($10,500, full time, $9.02-$11.32/h, 6 months), one GS-5 technician ($1,000) for rearing
There is no support from other funding sources.

Literature review:

Beavers, J. B. and C. O. Calkins. 1984. Susceptibility of *Anastrepha suspensa* (Diptera: Tephritidae) to steinernematid and heterorhabditid nematodes in laboratory studies. Environ. Entomol. 13: 137-139.

Lindegren, J. E. and P. V. Vail. 1986. Susceptibility of Mediterranean fruit fly, melon fly, oriental fruit fly (Diptera: Tephritidae) to the entomogenous nematode *Steinernema feltiae* in laboratory tests. Environ. Entomol. 15: 465-468.

Patterson Stark, J. E. and L. A. Lacey. 1999. Susceptibility of the western cherry fruit fly (Diptera: Tephritidae) to five species of entomopathogenic nematodes in laboratory studies. J. Invert. Pathol. 74: 206-208.

FINAL REPORT

WTFRC Project # 13C-3343-8122

Project title: GLP Magnitude of Residue Field Trials for thiocloprid, bifenazate and (AVG)[1].

PI: D.B.Walsh, Agrichem./Environ. Educ. Spec., WSU- Prosser

Organization: Department of Entomology, WSU

Co-PI: R. Wight, Field Research Dir., IR4 Project, WSU-Prosser

Objectives: To conduct the field phase of GLP magnitude of residue studies as outlined by the USDA IR-4 Project for the crop protection chemistries thiocloprid, bifenazate, and AVG.

Significant findings:
Thiocloprid is a second generation neo-nicotinyl compound that is produced by Bayer Chemical Company and will likely be marketed under the trade name Calypso™. A major advantage of thiocloprid compared to imidacloprid (Pravado™) is its' wider spectrum of control activity on many types of pest insects.

Bifenazate is a carbazate miticide that has been granted reduced risk status by the US EPA. Bifenazate will be marketed by Uniroyal on food crops under the trade name Acramite® . Bifenazate has proven to be a highly effective miticide against mite pests on cherries produced in Michigan.

AVG is a plant growth regulator marketed under the trade name Retain by Valent BioScience. AVG improves harvest management by inhibiting Ethylene Biosynthesis. Sweet cherries will be the second treefruit crop on which this product will be registered as a post-harvest treatment. Jim Adaskaveg at U.C. Riverside and Peter Sanderson, with the Tree Fruit Research Commission are familiar with this product and are encouraged by how its' use improves shelf life for cherries.

Methods: All three of these GLP magnitude of residue studies were conducted under a detailed protocol. If asked we can can provide a copy of part or the complete field data book for each of these projects.

FINAL REPORT

WTFRC Project no: CH-01-09

Title:	Large scale test of radio frequency radiation as a quarantine treatment against codling moth in cherry
PI:	J. D. Hansen, Research Entomologist
Organization:	USDA-ARS, Wapato, WA
Co-PIs and affiliations:	J. Tang, Food Engineer, WSU, Pullman, WA; S. R. Drake, Research Horticulturist, USDA-ARS, Wenatchee, WA
Collaborator:	E. J. Mitcham, Postharvest Physiologist, UC, Davis, CA

Objectives:
The objectives of this project were 1) to further improve the repeatability and efficiency of the radio frequency (RF) treatment method; 2) to conduct large scale testing to meet the Ministry of Agriculture, Forestry and Fisheries (MAFF)-Japan requirements, by demonstrating the efficacy of the RF treatment against the least susceptible infesting life stage by using a 30,000 treatment population of codling moth, a major step for official approval of the treatment by Japan; 3) to determine mortality on cherry fruit fly larvae by using the treatment intended for codling moth.

Significant findings:

- A series of tests were conducted to determine efficacy of warm water treatments. Two methods were developed based on cherries were produced: California and Pacific Northwest (PNW).

- For California cherries, the treatment was a 5 min prebath at 43°C (109 °F), followed by warm water exposure, either for 8 min at 48°C (118°F), 6 min at 49°C (120°F) or 4 min at 50°C (122°F), then hydrocool until fruit core temperature drops to about 4°C (39°F). The warm water exposure can be either a bath or a shower.

- For PNW cherries, the treatment was a direct warm water immersion for 6 min at 50° (122°F) or 4 min at 54°C (129°F), followed by hydrocooling until fruit core temperature drops to about 4°C (39°F).

- Initial tests indicated no significant adverse effect on fruit quality for both of these methods. Hydrocooling is for maintaining fruit quality and does not contribute to treatment efficacy.

- We observed no significant difference in the increase of fruit core temperatures between the bath and shower methods.

- The brief cold storage of California fruits had no impact on larval survival.

Methods:

1. Originally, this research was to be done with the RF unit to heat fruits in water. Because the unit did not arrive at the laboratory in for the cherry season, warm water treatments were used instead as surrogates for the RF treatments. These warm water treatments were appropriate because the rapid increase in core temperatures was comparable to that from a RF unit. The cherries were treated using two methods. The first method was conducted on California cherry using a shower

to deliver warm water. The second method was used on PNW cherries using direct immersion. All treatments were done using 50 ppm chlorine to reduce inoculation by pathogens in the water.

2. Immature 'Bing' cherries were obtained from California for early season fruits (average size: 12.3 Row, 5.8 g) and Washington for late season fruits (average size: 12.0 Row, 6.3 g). Codling moth larvae were obtained from the rearing colony at the Yakima Agricultural Research Laboratory (YARL). Each cherry was infested with third instar codling moth, 50 infested fruits per treatment replicate, then allowed overnight at room temperature to penetrate the fruits. California fruits were held in cold storage near freezing before treatment. Treatment evaluation was conducted the day following treatment. Control fruits were not treated in water, but held near room temperature 20°C (68°F) for the duration of the treatment. California fruits were subjected to cold storage.

3. To evaluate fruit quality after treatment, uninfested mature 'Bing' sweet cherries were treated the same as the infested cherries. The same criteria were used as for all previous quality evaluation studies. Quality studies were conducted at UC-Davis for California cherries and at the USDA-ARS Wenatchee Laboratory for PNW cherries. Quality parameters included firmness, Ssc, TA, etc. Particular attention was placed on stem color and shelf life (two weeks).

Results and discussion:
Although California cherries were treated cold, the prebath quickly warmed the fruits (Fig. 1.). The cold exposure by itself, as used in the controls, did not cause larval mortalities. There was no significant difference in fruit core warming rates using either the treatment bath or shower (Fig. 1). Complete efficacy (100% mortality) at the lowest temperature exposure was established with 8 min at 48°C (118°F) to 4 min at 50°C (122°F) of water temperature (Figs. 2 and 3).

Because the PNW cherries were treated at room temperature, they were not subjected to a prebath. This reflects the differences in commercial operations between California and the PNW. Complete efficacy was obtained with 6 min at 50°C (122°F) to 4 min at 54°C (129°F) (Fig.4). Any exposure below this resulted in survivors. Although the infested fruits used in both treatment methods were about the same size, cherries from the PNW are typically larger (Row 9 to 12) than those from California (Row 10 to 13). Thus, a longer treatment exposure will be required for PNW cherries.

Post-treatment hydrocooling is intended for maintaining fruit quality; comparison tests of efficacy between treatments with hydrocooling and those without indicate that hydrocooling does not contribute to efficacy treatment. Evaluations on fruit quality for either the PNW cherries (Fig.4) or those from California (Fig. 5) indicate that the efficacy is below the region where fruit injury occurs. Thus, there is flexibility so that a severe treatment required to obtain the probit 9 level (99.996832% pest mortality) may be obtained within the range of fruit tolerances. Furthermore, packing house operations do not have to be that precise in the timing of these treatments.

This research indicates that efficacious treatments against codling moth larvae can be obtained without causing long term damage to fruit quality for both California and PNW cherries. This is a major accomplishment in the development of quarantine treatments. Previously, it was thought that cherries could not tolerate temperatures required to control codling moth larvae. Yet, not only are the thermal exposures lower than the region of fruit damage, but these exposures can also be used for the basis of quarantine treatments against codling moth in other fruits. Further research is needed to define the limits of fruit quality and to factors affecting fruit injury from thermal treatments.

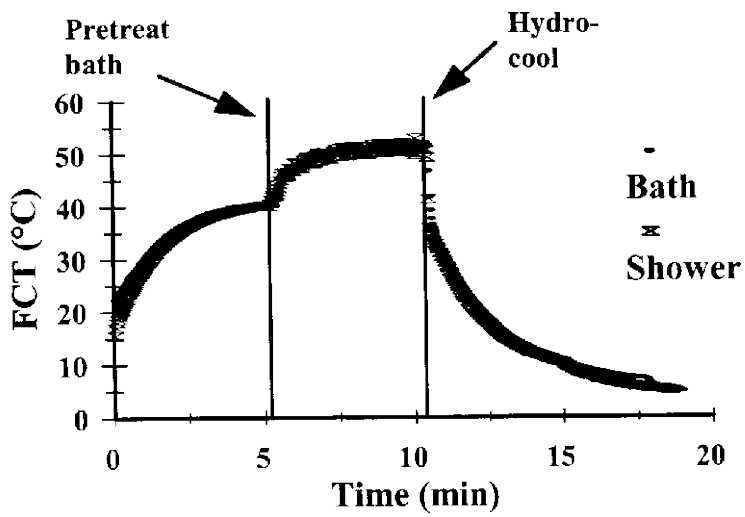


Figure 1. Typical temperature profile of the fruit core (FCT) of California cherry exposed to a 5 min prebath at 40^0C and either a 5 min bath or shower at 51.5^0C (125^0F), followed by 4^0C (39^0F) hydrocooling.

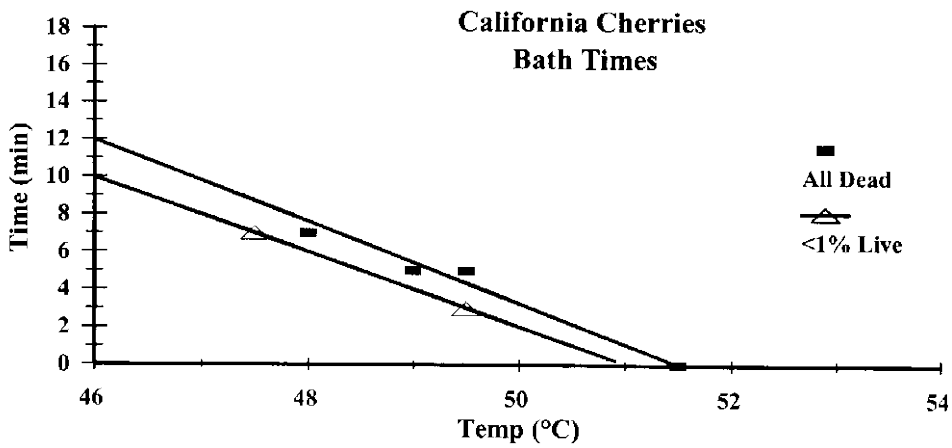


Figure 2. Treatment efficacy of California cherries when exposed to showers at specific temperatures for a range of durations.

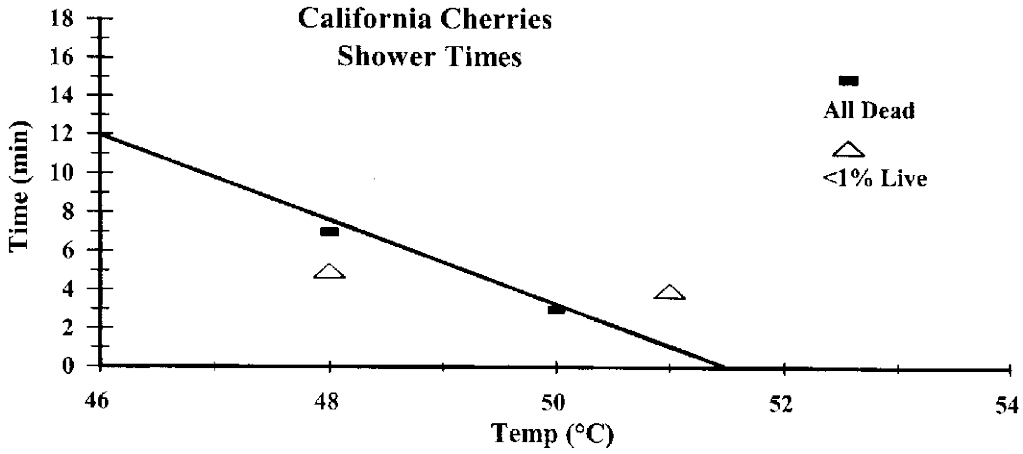


Figure 3. Treatment efficacy of California cherries when exposed to water baths at specific temperatures for a range of durations.

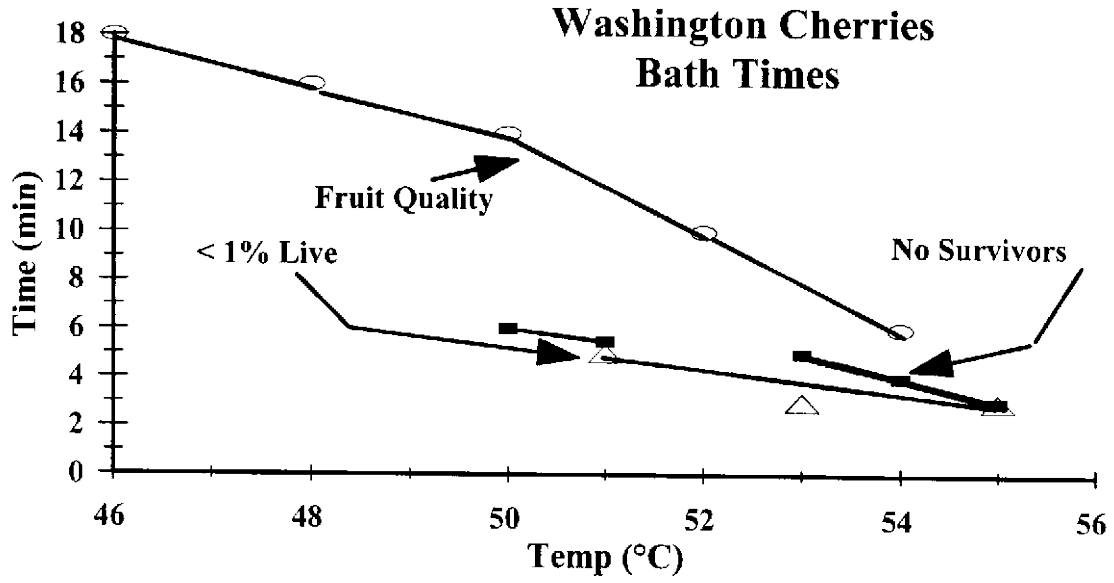


Figure 4. Treatment efficacy and fruit quality of cherries from the PNW when exposed to water baths at specific temperatures for a range of durations.

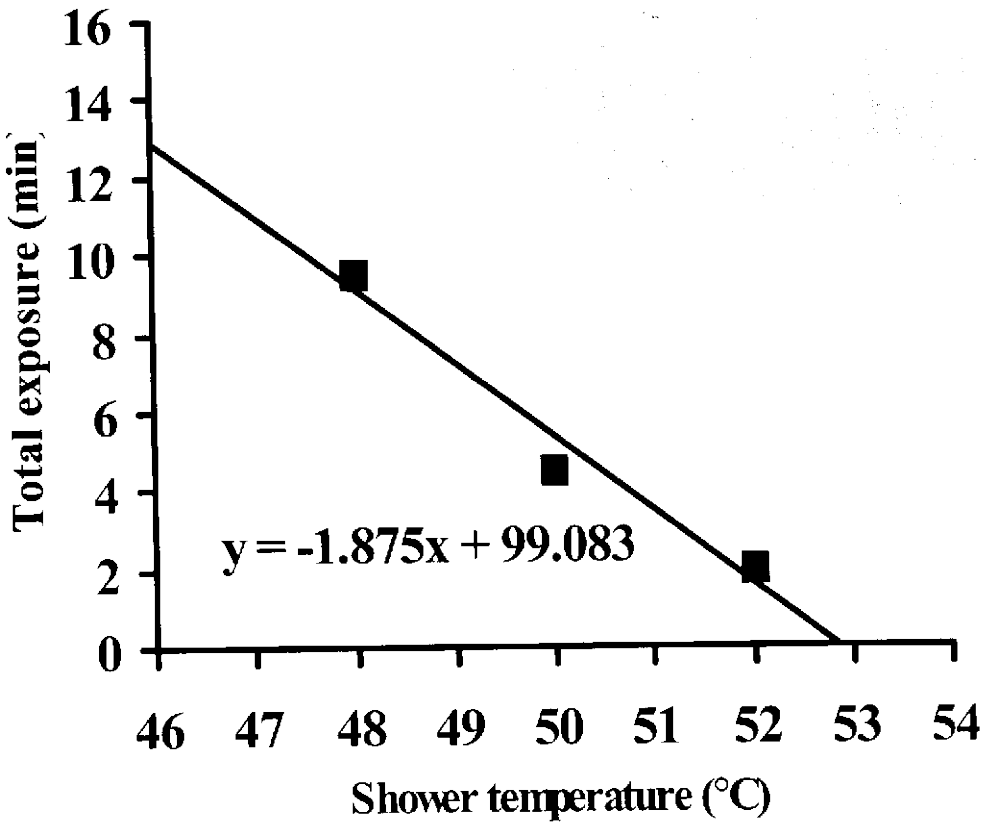


Figure 5. Based on California cherries, maximum treatment times at different temperatures form a linear regression line, beyond which fruit quality will be unacceptable after two weeks.

CONTINUING PROJECT **YEAR 4**

WTFRC Project # CH-01-06

Title: **Cherry Phytochemicals**

Principal Investigator: Ronald E. Wrolstad
Department of Food Science & Technology (FST)
Oregon State University
Phone: (541) 737-3591
E-mail: ron.wrolstad@orst.edu

Cooperators: Arusa Chaovanalikit, Ph.D. student, FST
Robert W. Durst, Sr. Research Assistant, FST

Collaborators: Paul Chen, Mid-Columbia Research & Extension Center
Anita Azarenko, Department of Horticulture, OSU
Carl Payne, Oregon Cherry Growers
Balz Frei, Linus Pauling Institute, OSU

Objectives:

- Identify and determine the concentrations of anthocyanin pigments and polyphenolics in selected cherry cultivars.
- Do comparative measurements of anthocyanin and polyphenolics in peel, flesh and pits, and monitor their changes when processed into frozen and brined fruit and juice.
- Determine the *in vitro* antioxidant activities of cherry extracts by the Oxygen Radical Absorbing Capacity (ORAC) and Ferric Reducing Antioxidant Potential (FRAP) assays.

Goals & activities for next year:

•Identification of individual polyphenolics and determination of qualitative and quantitative differences with respect to cultivar, distribution between peel, flesh and pit, and effects of processing. Anticipated completion is January, 2003.

Significant findings:

•The proportion by weight of peel, flesh and pits for Bing, Royal Anne, Ranier and Montmorency cherries has been determined for the 2001 season. Peel (17%), flesh (65%), pit (7%), loss (11%).

•Total anthocyanin pigments, total phenolics, and antioxidant activites have been determined for extracts of peel, flesh and pits for the four cultivars. Anthocyanin pigments, total phenolics and antioxidant activities are highest in the skin. Bing and Montmorency are highest in anthocyanin.

•Montmorency is highest in total phenolics, with Royal Anne being slightly higher than Bing in total phenolics. Ranier is lowest. Total phenolics has a high correlation with antioxidant activities as measured by ORAC and FRAP.

•Bing cherries from the 2000 season stored at –23°C for six months showed substantial (>50%) loss of anthocyanin in contrast to cherries stored at –70°C. There was a high correlation with decrease in antioxidant activity.

•Approximately 50% of the Bing cherry anthocyanins and total phenolics are distributed into the syrup with canning.

•Sulfite brining of Bing and Royal Anne cherries demonstrated that most of the phenolics were redistributed into the brine solution.

Methods:

Fruit Source

Cherry samples were collected from the Mid-Columbia Research and Extension Center (Paul Chen) and the Lewis Brown Farm (Anita Azarenko). Fruit for freezing, canning and brining processing studies were provided by Oregon Cherry Growers (Carl Payne).

Processing Trials

Bing cherries were canned and frozen in the OSU FST pilot plant using unit operations typical of commercial processes. Both Royal Anne and Bing cherries were used for brining experiments. Changes in both canned and frozen fruit will be monitored during storage over six months.

Sample Extracts

Materials will be cryogenically milled with liquid nitrogen, extracted with acetone and partitioned with chloroform to produce an aqueous extract as previously described (2001-2002 proposal).

Extracts of peels, flesh and pits for Bing, Royal Anne, Ranier and Montmorency cherries from the 2001 season are stored at –70°C. Extracts for frozen and canned cherries at zero storage time have also been prepared and stored and will be used for subsequent analyses.
Separation, Identification and Quantitfication of Individual Polyphenolics

Analytical and semi-preparative HPLC will be the primary analytical tools for separating and identifying anthocyanins and polyphenolics. Cherry anthocyanins have been identified and methods for separation and quantitation are in place (Hong and Wrolstad, 1990). Substantial effort will be directed to identification and measurement of the concentrations of the other polyphenolics— flavonols, flavan-3-ols, procyanidins, and cinnamic acid derivatives. Acid hydrolysis and saponification reactions will be used in conjunction with HPLC for partial characterization. Solid-phase extraction using C-18 resin will be used for isolating anthocyanin and polyphenolic fractions (Skrede et al., 2000).

Electro-Spray Mass Spectroscopy (ESMS)will also be used in conjunction with HPLC and UV-visible spectroscopy for polyphenolic identifications. ESMS analyses will be done at the OSU Department of Chemistry on a fee basis. Quantities of individual compounds will be measured by compound class (anthocyanins, flavonols, flavn-3-ols, procyanidins, cinnamates, etc.) with HPLC via the external standard method. Our laboratory is well experienced in these methodologies (Spanos et al., 1990; Karadeniz et al., 2000).

Measurement of Total Anthocyanins, Total Phenolics and Anti-oxidant Activity.

Total anthocyanins will be determined by the pH differential method (Wrolstad et al., 1982) and total phenolics by the Folin-Ciocalteau procedure (Singleton and Rossi, 1965).The antioxidant activity of cherry extracts will be determined by Oxygen Radical Absorbing Capacity (ORAC) and Ferric Reducing Antioxidant Potential (FRAP) assays and reported as Trolox equivalents. Analyses will be determined at the Linus Pauling Institute (Deborah Hobbs) on a fee basis ($110/sample).

Results and Discussion:

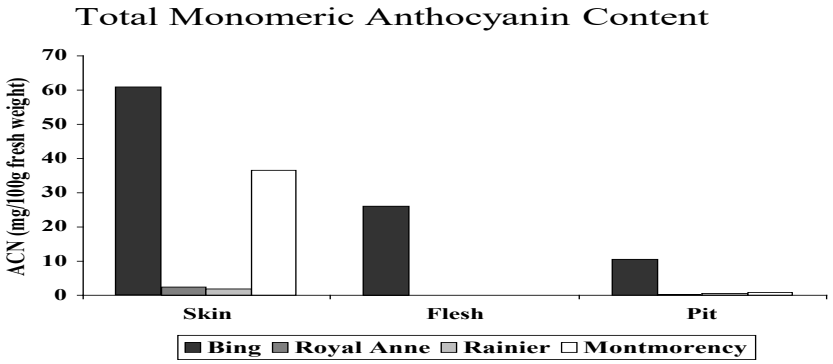
Distribution of Cherry Components by Weight

The proportion of cherry components in fruit samples for the 2001 season are shown in the following table: The proportions are similar for the different cultivars. The pits are a substantial source for polyphenolics.

Cultivar	% Flesh	% Skin	% Pit	% Loss
Bing	66	17	6	11
Royal Anne	62	18	8	12
Ranier	70	14	6	10
Montmorency	60	18	7	15

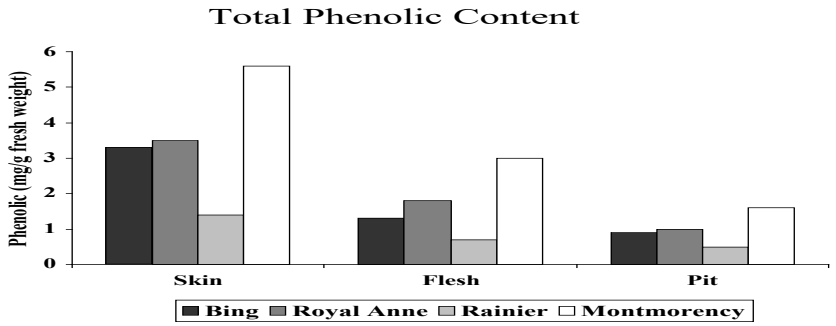
Distribution of Anthocyanin Pigments

The anthocyanin content of skin, flesh and pit for the four cultivars are shown in the following figure: Bing is richest in anthocyanin pigment and is the only cultivar which has pigmentation in the flesh. Montmorency contains substantial pigment in the peel, while Ranier and Royal Anne have light pigmentation. Pit pigmentation is likely from flesh material adhering to the pit.



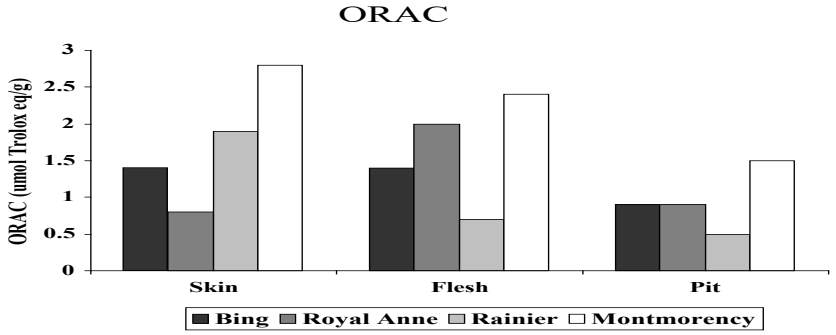
Distribution of Total Phenolics

Total phenolics as distributed in skin, flesh and pit for the four cultivars are shown in the following figure. Anthocyanins will contribute to total phenolics, but other polyphenolics (flavonols, flavan-3-ols, procyanidins and cinnamates) will also be measured. The peel is richest in phenolics. Montmorency is highest in total phenolcs for all components. Royal Anne cherries, while having very little anthocyanins, are slightly higher in total phenolics than Bings. Ranier is substantially lower in total phenolics than the other varieties.



Antioxidant Activities of Cherry Components

Antioxidant activity as measured by Oxygen Radical Absorbing Capacity (ORAC) for skin flesh and pit of the four cultivars is shown in the following figure. Montmorency is highest in antioxidant activity. While Royal Anne peel was higher in total phenolics than Bing, Bings are higher in ORAC; anthocyanins are very effective in traping free radicals which may account for this. Distribution of the different polyphenolics in these components are likely to account for these differences. Antioxidant activity was also measured by Ferric Reducing Antioxidant Potential (FRAP) and showed similar results.



Effect of Frozen Storage Temperature on Bing Anthocyanins and ORAC Activity

There was dramatic loss of anthocyanin pigments after storage for six months at –23°C as shown in the following table. Presumably this is caused by polyphenol oxidase activity.

Component	Anthocyanin pigment, mg/100g		ORAC, Trolox equiv/g	
	-70°C	-23°C	-70°C	-23°C
Skin	104	40	36.9	21.5
Flesh	46	17	16.5	9.5
Pits	18	4	6.3	5.7

Effect of Canning on Bing Cherry Anthocyanins and Total Phenolics

Bing cherries were canned and the distribution of anthocyanins and total phenolics in fruit and syrup measured after processing. Anthocyanins and phenolics are distributed almost equally between fruit and syrup. Samples are being monitored during storage over six months at 25 and 5°C.

Sample	Total Anthocyanins, mg/100g	Total Phenolics, mg/g
Fresh Bing Cherries	65.1	1.93
Canned Cherries	35.1	1.18
Syrup	29.9	1.38

Effect of Brining on Bing and Royal Anne Anthocyanins and Total Phenolics

Bing and Royal Anne cherries were brined and the anthocyanin and total phenolics determined for fruit before brining, and in fruit and brine after six months. Most of the anthocyanins and total phenolics are redistributed into the brine. Spent brine could serve as a source for these compounds in waste utilization.

Sample	Total Anthocyanin, mg/100g	Total Phenolics, mg/g
Fresh Bing Fruit	26.1	1.82
Brined Bing Fruit	0.53	0.16
Bing Brine	11.1	1.54
Fresh Royal Anne Fruit	0.19	1.50
Brined Royal Anne Fruit	0.09	0.20
Royal Anne Brine	0.12	2.56

References

Giusti, M. M. and Wrolstad, R. E. 2001. Unit F1.2.1-13. Anthocyanins. Characterization and Measurement with UV-Visible Spectroscopy. In, *Current Protocols in Food Analytical Chemistry* . R. E. Wrolstad (Ed). John Wiley & Sons, NY.

Hong, V. and Wrolstad, R. E. 1990. Use of HPLC separation/photodiode array detection for characterization of anthocyanins. J. Agric. Food Chem. 38: 708-715.

Karadeniz, F., R. W. Durst and R. E. Wrolstad. 2000. Polyphenolic composition of raisins. J. Agric. Food Chem. 48: 5343-5350.

Singleton, V. L. and J. L. Rossi. 1965. Colorimetry of total phenolics with phsphomolybdic phosphotungstic acid reagents. Am. J. Enol. Vitic. 16: 144-158.

Skrede, G., R. E. Wrolstad and R. W. Durst. 2000. Changes in anthocyanins and polyphenolics during juice processing of highbush blueberries (*Vaccinium corymbosum* L.) J. Food Sci. 65: 357-364.

Spanos, G.A. and R.E. Wrolstad. 1990. The influence of processing and storage on the phenolic composition of Thompson Seedless grape juice. J. Agric. Food Chem. 38: 1565 1571.

Budget:
Cherry Phytochemicals
Ronald E. Wrolstad
Proposed duration: 1999-2002
Current Year: 2002 (Request is for six months funding with project scheduled for completion 1/31/03)

Original Budget Request: (8/1/02-1/31/03)

Year	Year 1 (2000)	Year 2 (2001)	**Year 3 (2002)**
Total	20,000	20,000	**12,000**

Note:Year 1 was a preliminary study on cherry polyphenolics and antioxidant activity. Funds were expended for undergraduate student wages, antioxidant measurements and laboratory supplies.

Current year breakdown:

Year	Year 1 (2000)	Year 2 (2001)	**Year 3 (2002)**
Salaries	15,411	15,853	**8,943[a]**
Benefits	459	488	**429[b]**
Supplies	4,130	3,659	**2,628[c]**
Total	20,000	20,000	**12,000**

[a]Chaovanalikit, GRA, Ph.D, 0.49 FTE for six months, $8,532; Durst, Sr. Research Assistant, 0.02 FTE for six months, $411.

[b]Chaovanalikit, GRA OPE (3%); Durst, OPE (42%).

[c]HPLC supplies, extraction solvents; ORAC and FRAP analyses at Linus Pauling Institute at $110/sample; ESMS analyses at OSU Chemistry Dept at $150/hr.

CONTINUING PROJECT **YEAR 3**

WTFRC Project # CH-01-08

Project Title: Mechanical Harvester for Fresh Market Quality Stemless Sweet Cherries

PPINCIPAL INVESTIGATOR: Donald L. Peterson, Agricultural Engineer
USDA/ARS
Appalachian Fruit Research Station
Kearneysville, WV

Cooperators: Bob Harris, Dennis Hayden, Matthew Whiting

Objectives: The principal objective of this research was to develop a mechanical harvesting system for stemless, fresh market quality sweet cherries. Secondary objectives were to: (1) determine compatible tree training and cultural practices, (2) develop an effective fruit removal actuator and positioning system, (3) develop fruit catching/collecting components that minimize damage, and (4) test the system under field conditions to determine feasibility. Objectives for 2002 will be to (a) add an impactor to the catching unit developed in 2001 and, (b) test the harvesting system at multiple locations to elucidate harvester performance with various training system and cultural practices.

Significant findings:

- A two-piece experimental harvester was developed. One unit contained a rapid displacement actuator (RDA) to effect fruit removal, soft catching/collecting conveyors, and automated bin filler. The second unit contained the soft catching/collecting conveyors, automated bin filler, and a mechanism to seal around the tree trunk and connect the two units to prevent fruit loss to the ground.
- The machine operators using hydraulic joysticks effectively controlled the RDA and trunk seal mechanism.
- Tree training requirements were identified that improved removal and efficiency of harvester operation
- Even though ethrel was not effective in reducing fruit detachment force, fruit removal still averaged 80-90%.
- Machine harvested cherries averaged less than 4% stems
- Machine harvested fruit quality compared favorably with hand harvesting. On three cultivars, machine harvested sweet cherries had only 3-6% more damage than hand harvested cherries and averaged 79-88% fresh market quality
- The catching/collecting system was effective with low damage inflicted to the cherries.

Methods: In 2002 a RDA will be added to the collecting unit developed in 2001. Having an RDA on both units will permit determination of harvesting rates and capacity, and therefore better represent commercial potential. Since the 2001 unit contains the trunk seal mechanism, the original design of the RDA positioning mechanism will be modified to accommodate a slightly different operating sequence. The harvesters will be tested at three locations (Roosevelt, Processor, and Pasco) to evaluate different training techniques on harvester performance, and increase our chances for having effective ethrel response.

Results and discussion: All machine components operated as expected. After practice, the drivers easily controlled the positioning of the RDA and trunk seal. Conveyors and bin fillers were very

effective. Little fruit was lost between the two units. There appeared to be no limb damage from the RDA. Etherl was not effective in reducing fruit retention force. For 'Bing' fruit detachment force average 570 gms. Fruit removal was 80%. There was no significant different in fruit quality from either harvester unit. Machine harvested 'Bing' averaged 79% marketable, 17% natural culls and 4% damage. 'Bing' commercially hand harvested graded significantly different (5% Duncan Multiple Range Test) with 84% marketable, 15% natural culls and 1% damage. Machine harvested cherries averaged 3.7% stems with no significant difference between either unit. Harvested 20 trees in 15 minutes. With more compatible tree training and lower fruit detachment force, we expect practical harvest rates to be two to three times higher. 'Van' fruit detachment force average 360 gms and removal averaged 90%. There was no significant quality difference between machine and commercially hand harvested 'Van'. Machine harvest average 88% marketable, 7% natural culls and 5% damage. Hand harvest averaged 85% marketable, 11% natural culls and 4% damage.

Budget:
Mechanical Harvester for Fresh Market Quality Stemless Sweet Cherries
Donald L. Peterson
Project Duration: 3 years
Current Year 2002

Year	Year 1 (2000)	Year 2 (2001)	**Year 3 (2002)**
Supplies	6,500	28,000	**4,800**
Travel	7,000	7,000	**6,200**
Transportation	7,000	10,000	**9,000**
Total	20,500	45,000	**20,000**

* Per diem for 2 people for 21 days, car rental, and airfare for 2 people for harvester evaluation.
** Transportation of harvesters from West Virginia to Washington and return.

CONTINUING PROJECT **YEAR 6**

WTFRC Project #: CH-01-02

Title:	**Identification of sweet cherry dwarfing rootstock candidates from MSU's tart cherry germplasm collection.**
PI:	Amy Iezzoni
Organization:	Department of Horticulture, Michigan State University (MSU)
Co-PI's:	none
Cooperators:	Ron Perry (MSU), Bill Howell (NRSP5, Prosser) & Matt Whiting (WSU-Prosser)

Objectives: Identify rootstock selections from MSU's vast cherry germplasm collection that may have commercial potential as dwarfing precocious rootstocks for sweet cherry. MSU selections included as rootstock candidates in field trials at MSU and WSU will have been demonstrated to propagate well and to be virus tolerant.

This project consists of four stages:

1. Propagation: Years 1997 –2001 [completed this season]
2. Virus testing: Years 1998 – 2002 [the YR 2001 cuttings will be screened Winter 2002]
3. Planting of grafted trees in test plots: Years 2001 – 2004
4. Rootstock plot evaluation at MSU & WSU: beginning in YR 2001-MSU & YR 2002-WSU.

Years 2002 to 2004 represent Transition Years in which virus testing, budding and plot establishment will be sequentially completed. Year 2005 represents the first year where the only activity will be plot evaluation. Since the propagation phase was completed in YR 2001, the significant findings discussed below will reflect not only the YR 2001 findings but the findings from the entire propagation stage of this project.

Significant findings (Years 1997 to 2001):

- From a total of 340 MSU selections evaluated from 1997 to 2001, 89 rootstock candidates were identified based upon propagation ability and for a majority, virus tolerance. Forty-two of these selections propagated in YR 2001 need to be tested for virus sensitivity in YR 2002.
- In Spring 2001, 163 trees representing 19 Bing/MSU rootstock and 20 Hedelfingen/MSU rootstock combinations were planted at MSU (see photo below).
- Rootstock cuttings from YR 2001 propagation were sent to Meadow Lake Nursery (MLN) on Sept. 25 for budding for the WSU plot and will be taken (Oct. 2001) to Hilltop Nursery for budding for the MSU plot.

Results and Discussion:

This past spring, 163 Bing and Hedelfingen trees were planted at MSU's Clarksville Horticultural Research Station. The rootstocks were MSU rootstock candidates from YRs 1997 and 1998 cuttings that were budded at MLN. They were all planted at MSU since there would have been insufficient replicate trees if the trees were split between the MSU and WSU test sites. [It is not clear if the poor bud take at MLN was due to some trouble with propagation per se or to an early acting incompatibility that may have prevented the Bing/Hedelfingen buds from fusing to the rootstock]. To provide sufficient trees for both MSU and WSU plots, extra cuttings of the 1997 and 1998 selections were re-propagated this year. To not overload the propagation capabilities at Mast Greenhouse, we therefore reduced our initial number of new rootstock selections to 45.

Ninety-three percent of the YR 2001 selections exhibited suitable rooting (Table 1). One selection exhibited 100% rooting which was significantly better than GI 6 at 89%. This 93% was a dramatic improvement over the 30% acceptable rooting that was obtained for the 1997-2000 cuttings. The reason that the YR 2001 cuttings rooted so well was that they were from progeny ("second generation") plants that had been chosen based upon the results from the 1997 propagation. For example, seed from *P. fruticosa* selections that looked promising in 1997 were re-collected from the same hillside population in Pazmad, Hungary as the superior selections tested in 1997. In the MSU cherry program we were able to grow these "second generation" progeny vigorously to obtain plants large enough for cuttings in YR 2001. This demonstrates that in one breeding generation it was possible to increase the mean rooting % of the cuttings from 30% to 93%. This year's propagation was so successful that a large number of new selections will "enter the testing pipeline". All these new selections will need to be screened for hypersensitivity to PDV + PNRSV, dramatically increasing this budget line for YR 2002.

Results from the PDV + PNRSV screen at Prosser identified 10 YR 2000 cuttings that were virus hypersensitive and these 10 selections were subsequently discontinued in this project.

Because YR 2001 was the last propagation year, we split the cuttings for budding between 2 nurseries, MLN and Hilltop Nursery. This way, trees grafted with Bing intended for WSU will be made at MLN and trees intended for MSU will be made at Hilltop. The collection at Hilltop Nursery will also serve as a "back-up" since it will be possible for us to visit the cuttings in the nursery row a least every two weeks to provide any extra care necessary.

Table 1: A comparison of the YR 2001 MSU rootstock propagation results with the combined results from the 1997 and 2000 cuttings.

Trait	2001[1]	1997 to 2000
Number of selections screened	44 + GI 6	296 + GI 6
% of selections with zero rooting	3	42
Range of rooting (%)	9 to 100	6 to 97
Number of selections kept for testing	42	92
% of selections kept for testing	93	30

[1] The plants included in the YR 2001 experiment were progeny from plants that gave excellent results in YR 1997.

Methods and Objectives for the Transition Years (2002 – 2004):

YR 2002: Determine the virus tolerance/sensitivity of the remaining rootstock candidates, plant the grafted trees from the YR 1999 rootstock candidates in the MSU and WSU Rootstock Test Plots, and begin data collection from the grafted trees.

Table 2: Year 2002 activities.

	Winter	Spring	Summer	Fall
NRSP5	Virus test 50 selections[1]			
MSU		▪ Purchase pollinator trees[2]. ▪ Plant trees from YR 1999 cuttings plus pollinator trees in evaluation block. ▪ Plant YR 2000 cuttings in mother block. ▪ Plant YR 2001 cuttings in polyhouse. ▪ Record truck x-sectional area for trees planted in 2001.	▪ Re-evaluate plot maps and record any dead/sick trees.	▪ Data analysis and updating of planting/plot inventory
WSU		▪ Purchase pollinator trees[2]. ▪ Plant trees from YR 1999 cuttings plus pollinator trees in evaluation block. ▪ Travel to Prosser to assist with planting[3]		▪ Travel to the west coast for the Cherry Research Review[3].
Hilltop		▪ Plant YR 2001[4] cuttings in nursery row.	▪ Assist in budding YR 2001[4] cuttings	
MLN			▪ Travel to MLN to inventory/re-tag YR 2000 and 2001[4] cuttings, and initiate any identification procedures necessary[3].	

[1] This total includes 42 selections from the YR 2001 propagation and 8 selections that were previously screened but results were not obtained.
[2] The rootstock candidates for MSU and WSU will be budded with Hedelfingen and Bing, respectively. Therefore, for each test plot, pollinator trees (MSU-Ulster/GI 6; WSU-Tieton/GI 6) need to be purchased so that the Bing/Hedelfingen : pollinator ratio is 8:1.
[3] *Funds are requested to travel to Prosser to assist in planting and recording the correct map, MLN to tag and verify the status and identity of the rootstock selections, and the West Coast for the Cherry Research Review. Miss-labeled selections may have to be differentiated using either morphological or DNA differences.*
[4]Year 2001 cuttings not only includes the 42 new rootstock candidates but 35 rootstock candidates that needed to be re-propagated to assure a complete set of cuttings at MSU and WSU.

YR 2003: Plant trees generated from the YR 2000 rootstock candidates in the MSU and WSU Rootstock Test Plots, verify labeling of trees for YR 2004 planting, and collect data from the grafted trees.

Table 3: Year 2003 activities.

	Spring	Summer	Fall
MSU	▪ Purchase pollinator trees[1]. ▪ Plant pollinator trees and trees from the YR 2000 cuttings. ▪ Minimal tree training and pruning. ▪ Take trunk-cross sectional area, and any bloom data from rootstock plot. ▪ Plant YR 2001 cuttings in mother block.	▪ Re-evaluate plot maps and record any dead/sick trees. ▪ Investigate any selections that may be miss-labeled either by morphological or DNA differences. ▪ Evaluate crop load and fruit size from any fruiting trees.	▪ Data analysis and updating of planting/plot inventory
WSU	▪ Purchase pollinator trees[1]. ▪ Plant pollinator trees and trees from the YR 2000 cuttings. ▪ Minimal tree training. ▪ Take trunk-cross sectional area. ▪ Travel to Prosser to assist with planting and data collection.		▪ Travel to the West Coast to attend the Cherry Research Review.
Hilltop		▪ Re-label budded trees in the nursery row that were from YR 2001 propagation.	
MLN		▪ Travel to MLN to re-label budded trees in the nursery row that were from YR 2001 propagation.	

[1] The rootstock candidates for MSU and WSU will be budded with Hedelfingen and Bing, respectively. Therefore, for each test plot, pollinator trees (WSU-Tieton/GI 6; MSU-Ulster/GI6) need to be purchased so that the Bing/Hedelfingen : pollinator ratio is 8:1.

[2] *Funds are requested to travel to Prosser to assisting in planting, map generation and data collection, MLN to tag and verify the status of the budded trees, and attend the Cherry Research Review.*

[3] Data collected: trunk cross-sectional area, bloom date, bloom density, crop load, & fruit size as the trees mature.

YR 2004: Complete the planting phase of the rootstock project at MSU and WSU & continue with data collection.

Table 4: Year 2004 activities to be accomplished by Amy Iezzoni and/or Audrey Sebolt (MSU cherry breeding technician).

	Spring	Summer	Fall
MSU	▪ Purchase pollinator trees[1]. ▪ Plant pollinator trees and trees from the YR 2001 cuttings. ▪ Minimal tree training and pruning. ▪ Take bloom and x-sectional area data[2].	▪ Re-evaluate plot maps and record any dead/sick trees. ▪ Evaluate crop load and fruit data[2].	▪ Data analysis and updating of planting/plot inventory.
WSU	▪ Purchase pollinator trees. ▪ Plant pollinator trees and trees from the YR 2001 cuttings. ▪ Minimal tree training and pruning. ▪ Travel to Prosser to assist in the data collection [bloom and x-sectional area data.][2,3]		▪ Travel to the West Coast to attend the Cherry Research Review.

[1] The rootstock candidates for MSU and WSU will be budded with Hedelfingen and Bing, respectively. Therefore, for each test plot, pollinator trees (MSU-Ulster/GI 6; WSU-Tieton/GI6) need to be purchased so that the Bing/Hedelfingen : pollinator ratio is 8:1.
[2] Data collected: trunk cross-sectional area, bloom date, bloom density, crop load, fruit size. Crop load and in special cases actual yield data plus fruit size will be only collected from the most promising selections. Rationale: There is no need to record data from selections that are not performing well and will obviously be discarded.
[3] Funds are requested to travel to Prosser to assist in planting and the evaluation of trunk cross sectional area and any possible bloom data.

YR 2005: Evaluate the MSU rootstock candidates planted in field plots at MSU and WSU for their ability to induce dwarfing and precocity. Record cross-sectional area, bloom and fruit ripening date, fruit size, and estimates of bloom density and crop load. Crop load and in special cases actual yield data plus fruit size will be only collected from the GI 6 control and the most promising selections. Rationale: There is no need to collect data from selections that are not performing well and will obviously be discarded.

Propagation for advanced trials of promising selections will be initiated when and if any of the selections look promising.

Budget:
Identification of sweet cherry dwarfing rootstock candidates from MSU's tart cherry germplasm collection.
Amy Iezzoni
Project duration: Propagation Phase (1997-2001), Transition Phase (2002-2004), Field Testing will be the only activity beginning in YR 2005. The budget for YR 2001 is listed in italics along with the requested budget for the Transition Phase (YRs 2002 to 2004) .

Budget request:
Identification of sweet cherry dwarfing rootstock candidates from MSU's tart cherry germplasm collection.
Amy Iezzoni

Year	*Year 5 (2001)*	**Year 6 (2002)**	Year 7 (2003)	Year 8 (2004)
Total	*$ 15,000*	**$10,600**	$5,991 *	$5,647 *

* These numbers will increase depending on tree costs.

Budget breakdown:

ITEM	*Year 5 (2001)*	**Year 6 (2002)**	Year 7 (2003)	Year 8 (2004)
Salaries[1]	*$ 1,760*	$2,015	$2,116	$2,222
Benefits [2]	*497*	621	675	725
Labor	*7,000*	1,000 [3]	500	500
Supplies [4]	*1,463*	200	200	200
Fee at Mast Greenhouse	*0*	-	-	-
Shipping to MLN	*500*	-	-	-
Fee for virus screening	*1,080*	3,000 [5]	-	-
Travel	*2,500*	3,000 [6]	2,500[6]	2,000[6]
Tree and freight costs	*200* [7]	764 [8]	NA[9]	NA[9]
Plot costs at MSU	*0*	0	0	0
Plot costs at WSU	-	0	0	0
TOTAL	*$15,000*	**$10,600**	$5,991[9]	$5,647[9]

[1] This represents partial funding for technical support to oversee the budding at Hilltop, develop spreadsheets describing each rootstock selection and the status of all the grafted trees, assist in data collection, and manage, analyze, and summarize the data from the 2 field plots.
[2] Benefits for YRs 2002, 2003 and 2004 are calculated at 30.8%, 31.9%, and 32.6 %, respectively.
[3] Student labor in YR 2002 will assist with planting the YR 2000 cuttings in the mother block, YR 2001 cuttings in the polyhouse, data collection and identification of potential mix-ups. In subsequent years, student labor needs will be only to assist with data collection and management.
[4] Supplies to include tags and other minor field supplies, computer diskettes etc, and poster supplies.
[5] Fee from NRSP5 for virus screening 50 selections for PDV + PNRSV @$60 each. This includes 42 selections newly propagated in YR 2001 plus 8 selections where previous screen was not successful.
[6] Travel to WSU and to MLN in YRs 2002 and YR200 to assist in planting, field map development, tree labeling and data collection. Besides the obvious benefit of looking at the trees ourselves we are familiar with all the rootstock nomenclature and can more easily verify the accuracy of the labeling, map generation, and data collection. In YR 2002 there will also be numerous trips to Hilltop Nursery.
[7] A total of 163 trees were donated from MLN. The $200 represents freight charges.
[8] Pollinator trees for the MSU and WSU plots will be donated by Hilltop Nurseries and MLN, respectively. There are 94 trees for Spring 2002 planting that will be purchased from MLN @$6/tree. Freight charges are also included.
[9] Not available (NA): Tree costs for subsequent years will depend upon final tree number and whether the trees are donated or require payment. Therefore these budget requests will increase if there are any tree costs.

CONTINUING PROJECT **YEAR 6**

WTFRC Project #: **Organization Project #: 13C-3361-3201**

Project title: Sweet Cherry Genotype Research Consortium (GRC)
PI: W.E. Howell, NRSP5/IR2 Manager, WSU-Prosser

Organization: Washington State University – IAREC, Prosser

Co-Investigators & affiliations:
L.E. Long, Chair, Wasco Co. Extension, The Dalles
Bill Proebsting, Oregon State University, Corvallis
D. Ophardt, Agric. Res. Tech Lead, WSU-Prosser

Objectives:
1. Identify and prioritize international sources of potentially superior sweet cherry varieties and rootstock genotypes for safe importation to the PNW.
2. Efficiently develop and coordinate critical genotype screening tests for key PNW sweet cherry production regions.
3. Cost-effectively develop and coordinate critical horticultural evaluations for key PNW sweet cherry production regions and integrate results into a comprehensive computer database for PNW industry access.

Significant findings:
For the past five years, scientists from Washington State University, Oregon State University, and other land grant institutions collaborated with cherry scientists around the world to import and evaluate new cherry fruit and rootstock clones. The Washington Tree Fruit Research Commission (WTFRC), the Oregon Cherry Commission (OCC) and other granting agencies supported these efforts. During this time many new cherry rootstock and fruit selections were imported, virus-tested (provided virus therapy, if necessary), and released from quarantine to the WSU-Prosser cherry research program to propagate and increase for evaluation by the science and industry communities in the Pacific Northwest.

The primary objective for these efforts is to assist the Pacific Northwest sweet cherry industry to remain internationally competitive. The GRC collects and provides information on the new cherry selections for possible utilization by PNW growers. Obviously, this information needs to be based on sound data obtained in appropriate settings and not from observations and innuendo based solely on foreign data and vested interests.

The imported clones represent promising sweet cherry cultivars and rootstocks identified in travels of PNW cherry scientists, extension agents, growers, and nurserymen. The present cherry selections originate from Turkey, Germany, Australia, Latvia, Ukraine, Hungary, and Italy. The U.S. plant quarantine system can be a significant barrier to rapid importation and testing of such materials. However, the quarantine system is important for helping to prevent inadvertent introduction of potentially devastating diseases or insects. A key component for the rapid introduction and evaluation of imported fruit tree varieties for the GRC is the NRSP5 facility at WSU-Prosser. Improved quarantine testing procedures conducted by NRSP5 clears plant material safely and as quickly as possible. Furthermore, early evaluation of new cultivars for sensitivity to viruses common to the Pacific Northwest is conducted in its greenhouses, helping to quickly obtain data important to decisions on these new clones. These features of NRSP5 assist the GRC in its goals to coordinate rapid and cost-effective testing of new cherry materials.

This improved efficiency in critical testing, combined with the collaborative expertise of cherry scientists from, not only the PNW but, throughout the world attracts numerous international cherry breeding programs to offer their advanced cultivars and rootstocks for coordinated PNW evaluation. With GRC funding primarily by the WTFRC and OSCC, an industry advisory committee of Washington and Oregon growers works with the GRC scientists to prioritize and select those materials for which PNW resources are expended. The goals of the GRC scientists and industry advisors are to increase the pace and cost-efficiency of identification, importation, and critical evaluation of promising sweet cherry varieties and rootstock genotypes, developing objective scientific data for the ultimate purpose of increasing PNW industry knowledge for future production and marketing decisions.

Methods:
The GRC scientist and industry 'network' continually identifies promising new cherry variety and rootstock genotypes from around the world which, in consultation with the GRC industry advisory committee, are prioritized for potential impact on the PNW cherry industries. Testing agreements are then signed with the originators or licensed sponsors of the target genotypes and budwood or plants are acquired during the dormant season. All plant materials are sent to the NRSP5/IR2 facility at Prosser to be propagated for virus-indexing and other GRC tests. Those that are free of viruses, viroids, and phytoplasmas can be released provisionally for further propagation and testing under field conditions. Those testing positive during indexing can undergo Consortium laboratory screening procedures, such as rootstock virus sensitivity tests, while still in quarantine before any decision must be made regarding virus elimination therapy (heat treatment) to attain a provisional or full release status.

Consortium laboratory screening includes a battery of virus inoculation techniques for rootstocks to detect potential sensitivities to "normally symptomless" viruses endemic to the PNW, such as PDV and PNRSV. Other laboratory tests, including possible molecular techniques, to screen rapidly for susceptibility or resistance to other common PNW pathogens (*e.g.*, bacterial, powdery mildew) or critical genetic traits (such as rootstock/scion incompatibility and pollen compatibility groups) are under consideration or development.

Horticultural evaluations are to be conducted in secure, high density one acre Post-Entry Quarantine plots at WSU-Prosser, OSU/The Dalles, and OSU/Corvallis. Once adequate tree numbers are developed each site will optimally contain 5 replicates of each test accession. 'Bing' and 'Royal Anne' (as site appropriate) are the standard test cultivars for rootstock evaluation, and the precocious Gisela 5 or Gisela 6 rootstock are standard to induce rapid flowering and fruiting of new cultivars. The focus is to move new genotypes through the evaluation program rapidly, efficiently, and cost-effectively, so that the PNW industry can determine whether to follow up with independent, larger-scale field and marketing tests.

Vigor control, precocity, and yield efficiency of new rootstocks can be determined within five years of planting. Fruiting evaluations for new cultivars on precocious rootstocks are expected to provide three years of comparative flowering, yield and fruit quality data during the same period. At first flowering, each genotype's pollen compatibility group can be determined. At second and third flowering, budsticks could be used for controlled freezing or growth chamber forcing to determine relative cold hardiness and dormancy chilling requirements. Other critical tests may be developed as the industry and/or GRC scientist network identifies further needs or technological advances.

The information generated by the GRC includes compilations of observations and test data from international sources on potential target genotypes, as well as the GRC's own critical testing of those

plant materials that are introduced into the GRC testing program. Both types of information are standardized when possible and compiled into a computer database of sweet cherry cultivars, complete with color pictures of fruit when available. During winter, the updated GRC cherry database is printed to compact disk (CD-ROM) for distribution to GRC scientists for further feedback and input.

Results and discussion:
Of the 45 new cherry rootstock and fruiting selections whose importation was facilitated by the GRC during the past 4 years, 29 are at full release status from quarantine. An additional 9 are on provisional release status. Most of the released selections were propagated for budwood increase in the fall of 2000 and again this fall at WSU-Prosser. Propagations in 2001 were made to Gisela 6 and/or mahaleb rootstocks. Bill Proebsting, GRC cooperator at Oregon State University, provided the Gisela 6 for this work. Most of the propagated trees will be available for pomology evaluations. Others are located in an isolated location and will eventually be capable to provide budwood for establishing virus-certified trees at nurseries.
The other 7 imported cherry clones still contain virus. These are continuing to undergo virus therapy (heat treatment) at NRSP5. They can be released from quarantine after virus-negative clones of these selections are established and verified by further testing.

In addition to the results provided last year on the virus sensitivity of the NC140 cherry rootstock candidates, 2 new rootstock clones from Russia were screened in field tests this year. Neither, showed virus sensitivity, but those results are preliminary until final observations are completed next summer. Results of virus sensitivity tests for the NC140 cherry rootstocks that were inoculated in 1999 were unchanged from last year. In greenhouse tests Piku 1.10 and Piku 4.11 cherry rootstocks grew in the presence of PDV and PNRSV suggesting they are not hypersensitive to these viruses. However, they did show leaf symptoms, which indicates some vulnerability.

The WSFTRC and OSCC funded the fees required for virus testing of many of these cherry selections at NRSP5/IR2 either directly or through the GRC and the cherry variety research cooperative (CVR-COOP). USDA research grants obtained by GRC scientists covered the importation costs for the cherry clones from Latvia and the Ukraine.

Budget:
WTFRC and OSCC approved funding for the sweet cherry genotype research consortium (GRC) from 1997 to 2002. Although that funding period will soon terminate, present accomplishments by the project will not be fully maximized for another few years. Thus, it seems prudent to request a funding commitment for an additional 5 years. However, since the lead position for this project is presently vacant, we are presently requesting a commitment of funds for this year only. Upon filling of the vacant position during this coming year, the new scientist in collaboration with others should present a new and updated set of objectives, procedures, and funding requests for the GRC.

Given that no further importations are pending and since trees propagated for evaluation are still juvenile, the present funding needs for the GRC are reduced. Also, with the lead scientist's position for this project temporarily vacant, the budget requests for this year primarily reflect costs for propagation, development and distribution of test trees. Some trees will be available for planting to test sites in the spring of 2003. Increased funds for plot maintenance and for data collection will be needed at that time. In the meantime, for scientists interested in the gene pool represented by this collection of new cultivars, the trees are available for pathogen studies (such as powdery mildew) or other investigations.

Budget:
Sweet Cherry Genotype Research Consortium (GRC) – a continuance.
W.E. Howell
Project duration: 1997-2003
Current year: 2002-2003
Original budget request:

Year	Year 3 (1999)	Year 4 (2000)	Year 5 (2001)	**Year 6 (2002_**
Total	14,530	15,530	CVR-Coop[1]	**1,590**

Current year breakdown:

Item	Year 3	Year 4	Year 5	*Year 6*
Salaries	5,100	5,500		**1,051**[2]
Benefits (32%)	1,632	1,760		**336**
Wages				
Benefits (%)				
Equipment				
Supplies	7,798	8,270	9,000	**203**
Travel				
Miscellaneous				
Total	14,530	15,530	9,000	**1,590**

[1] Funds residing in the cherry variety research cooperative (CVR-Coop) account were designated to cover GRC costs for the 2000-01 budget year.
[2] Salaries: 2 weeks salary (technical assistant for tree propagation, tree maintenance and distribution - Greenhouse Attendant).
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FINAL REPORT CH-01-04

Project Title: ISHS International Cherry Symposium

Project Leaders: Lynn E. Long, Anita Azarenko, Oregon State University

Cooperators: *Roberto Nunez, Tim Facteau, Oregon State University*
Gary Grove, Gene Kupferman, Washington State University
Greg Lang, Michigan State University
Frank Kappel, Agriculture Canada

Funding History: 2001 - 2002: OSCC and WTFRC $8,000

Objectives: The Symposium focused on both sweet and tart cherry research, bringing together the latest results and technologies from academic institutions, research centers, industry scientists, graduate students, and progressive growers from around the world. Oral, poster, and workshop sessions, as well as field tours, were scheduled to help foster information and idea exchanges among participants.

Results and Discussion: One hundred sixty-seven participants attended the Symposium from 27 countries. Scientists from Canada, Hungary, Australia, Italy, the UK, France and the USA reported on new sweet cherry varieties developed in those countries. There were 138 papers and posters presented including "Effects of various rootstocks on the growth of '0900 Ziraat' sweet cherry in Turkey", "Spur extinction training of sweet cherries in France", and "The influence of different rootstocks on leaf mineral composition and fruit quality of 'Lapins' sweet cherry". But perhaps the greatest accomplishment of the symposium was the success of the Breeding and Genetics working group that successfully brought together all of the scientists from around the world who are working on S-allele compatibility issues. Scientists were able to agree on a standard nomenclature for the existing known S-alleles, as well as protocols for those that may yet be discovered, which should eliminate confusion in the literature that arose due to the use of differing terminology for previously mis-assigned or recently discovered S-alleles.

The Symposium program was split between two locations, Hood River, Oregon, and Richland, Washington. Orchard tours were concentrated in The Dalles, and the Yakima Valley. In addition participants had an opportunity to visit the OSU Mid Columbia Agriculture Research and Extension Center in Hood River and WSU's Irrigated Agricultural Research and Extension Center in Prosser. A pre-symposium tour in the Willamette Valley consisting of 54 participants visited tree fruit nurseries, orchards, and Oregon State University's research farm. A 3 day post-symposium tour of Washington's Columbia Basin and British Columbia's Okanagan valley was led by Tim Smith of WSU and Dr. Frank Kappel of Agriculture Canada. In addition, non-participating growers and industry personnel had an opportunity to interact with selected scientists from around the world in a panel discussion that explored the strengths and weaknesses of the Pacific Northwest tree fruit industry.

Budget -- 2001

OSU Conference Services	$4,836.92
Audio Video Technology Technician	$1,000.00
Conference Room Rentals	$2,163.08
Total	$8,000.00