FINAL PROJECT REPORT

Project Title: Efficient production of superlative fruit

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Total Project Funding:

Budget History:

Item	**Year 1:** 2007	**Year 2:** 2008	**Year 3:** 2009
Salaries			
Benefits			
Wages			
Benefits			
Equipment			
Supplies			
Travel			
Panel Testing			
Miscellaneous			
Total	136,138	137,386	140,766

OBJECTIVES

1. Improving efficiency (e.g., labor, pesticides, light use) through development of single-plane, compact orchard systems designed to incorporate mechanization and/or mechanical-assisted operations.
2. Develop pragmatic strategies for consistent and balanced cropping through understanding factors limiting fruit set and researching practical thinning strategies
3. Better understand critical fruit sensory attributes, consumers' perceptions of fruit quality, and their willingness to pay for those attributes

SIGNIFICANT FINDINGS (2009 only)

ORCHARD SYSTEMS

- In WSU and collaborator orchards, a novel architecture dubbed U.F.O. (upright fruiting offshoots) shows great potential for improving input efficiency and incorporating mechanization
- Key issues for establishing and maintaining the UFO architecture are 1) promoting uniform, well-spaced uprights in years 1 & 2, and 2) tree density (i.e., uprights/tree) for uniform, balanced growth of uprights.
- Industry collaboration has been significant, we estimate >25 acres of UFO plantings are established with UFO plantings also established in Chile, Argentina, and Australia
- 3^{rd}-leaf yields of UFO orchards were between ca. 1.5 and 5 tons/acre
- Summer pruning vigorous uprights is effective for reducing vigor
- Key issues for further research are: 1) potential for sleeping eye or fall planting systems; 2) cost:benefit analyses of fruiting wall systems
- Funding for continued development of the UFO training system was secured via the Specialty Crop Research Initiative

FRUIT SET/CROP LOAD MANAGEMENT

- Pollen germination was similar on the stigmas of cultivars with low fruit set (Benton, Regina) and high fruit set (Bing, Sweetheart)
- Temperature affects pollen germination and pollen tube growth rate
- Pollen tube growth is similar in high and low fruit set cultivars
- Ovule longevity appears to limit fruit set in many low set cultivars.
- Paternal elements do not appear to limit fruit set.
- The combination of GA_3 or $GA_{4/7}$ (30 ml l^{-1}) with Prohexadione-Ca at 150 mg l^{-1} (PCa, Apogee®) applied at the onset of endocarp lignification of fruit (30 days after full bloom) increased fruit weight and firmness significantly and similarly, by about 15%.
- 'Bing' fruit treated with PCa+GA_3 or PCa+$GA_{4/7}$ exhibited delayed fruit maturity of ca. 7 days compared to untreated control.
- Treatment with PCa + $GA_{4/7}$ resulted in 35-40% of fruit in ≤9 row size compared with only 20% of untreated fruit in the same size class. PCa + GA_3 however increased yield of similar, premium size fruit to 80%, regardless of application timing.
- Following 30 days in 4C storage only 5% of fruit were marketable from untreated trees whereas 50 – 30% fruit were marketable from PCa+GA_3 treatment
- The effect of a single GA_3 spray on sweet cherry fruit size is sensitive to the timing of application – applications earlier than straw appear to be beneficial

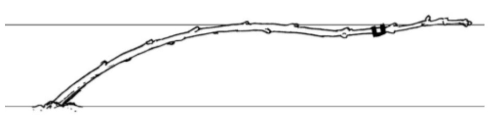
SENSORY STUDIES

- Overall, consumers have difficulty identifying differences in fruit firmness, particularly at high firmness levels

- When evaluating ‘Chelan’ fruit firmness, consumers were able to distinguish between low and high firmness, and low and intermediate firmness cherry groups.
- For ‘Bing’, consumers were able to distinguish only between low and high firmness cherry groups.
- For both harvest times, panelists did not distinguish between cherries from the same firmness group, or between intermediate and high firmness cherries.
- Consumer acceptance of cherry appearance, flavor, juiciness and firmness significantly influenced the overall acceptance of the cherry. Overall acceptance was not as influenced by appearance as it was by flavor.
- Acceptance of cherry firmness and juiciness significantly differed between early and late harvest cherries, with the early harvest cherries having a higher acceptance based on both of these attributes.

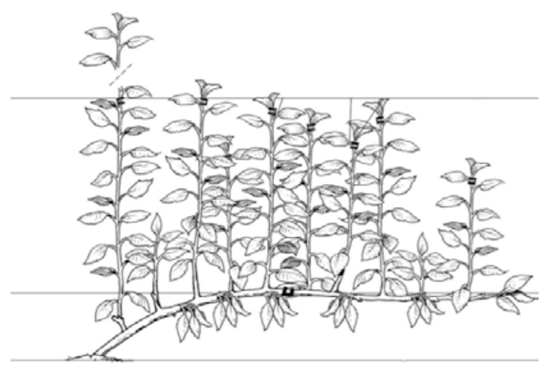
RESULTS AND DISCUSSION

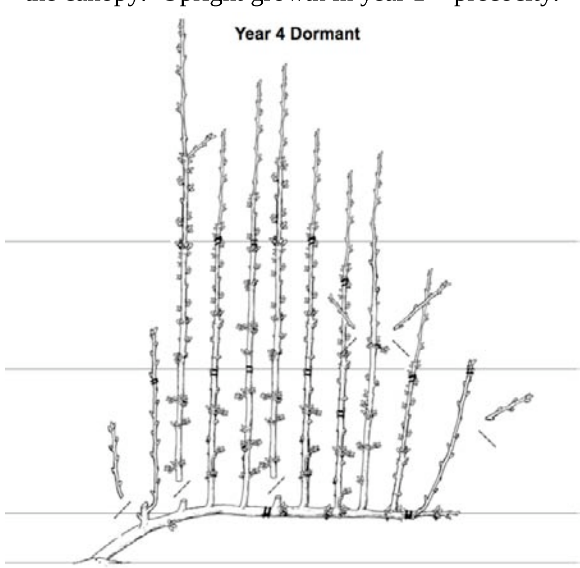
ORCHARD SYSTEMS We continued our collaborative development of planar fruiting wall architecture for high efficiency sweet cherry orchards – the UFO system. We currently are working with an illustrator to finalize a one-page (two-sided) handout for industry, illustrating the key training steps. This information will be posted also online at: http://fruit.prosser.wsu.edu/UFO.html. Third-leaf yields in a collaborating orchard ranged from 1.5 tons/ac (‘Early Robin’/’Gisela®6’ and ‘Kiona’/’Gisela®5’) to about 5 tons/ac for ‘Cowiche/’Gisela®5’. Yield of 3rd-leaf ‘Selah’/’Gisela®6’ was estimated at 4.5 tons/ac.



Unheaded whips are planted at an angle of 45° and brought horizontal gradually. Height of first wire should be 18 - 22". Recommended spacing: 8 – 10' x 6 – 8' (vertical walls), 13-15' x 3 – 4' (angled walls). Size-controlling, precocious rootstocks are recommended. Goal is to fill between-tree space at planting.

First growing season – develop wall of well-spaced uprights (6" apart), summer prune vigorous uprights. Remove uprights originating near base of scaffold and those that can’t be trained vertical. Ideal vertical growth is 20 - 30"/upright. Goal is to grow abundant, uniform upright shoots, establishing the canopy. Upright growth in year 1 = precocity.





Dormant, yearly (4 yr old illustrated) – prune lateral growth with thinning cuts leaving unbranched uprights. Renew uprights with stub cuts (i.e., leaving multiple renewal growing points). Regrowth from renewal pruning is thinned to a single upright.

FRUIT SET/POLLINATION Our investigations of environmental factors affecting fruit set continued in 2009. We have utilized four model cultivars: 'Bing' (high natural fruit set, self-sterile), 'Tieton' (low fruit set, self-sterile), 'Benton' (low fruit set, self-fertile), and 'Sweetheart' (high fruit set, self-fertile). We are combining field studies with others in temperature controlled growth chambers. Pollen germination, pollen tube growth rate, ovule viability, and stigma receptivity are each being assessed. This report will focus on pollen tube growth assessments.

From manual pollinations of recently opened flowers in temperature controlled growth chambers, we observed pollen germination as early as 2 HR post pollination, in Sweetheart at high temperature (Table 1). The growth of pollen occurred at a similar rate among cultivars and was inhibited at low temperature. At low temperature, initial pollen germination and growth did not occur until 24 to 32 HR post pollination. There was no apparent inhibition of pollen germination or pollen tube growth in the low productivity cultivars Benton and Regina, compared to the high productivity cultivars, Bing and Sweetheart. Similarly, there was no apparent difference among self-fertile and self-sterile cultivars. Temperature was the most influential factor. Overall, there were only subtle differences in pollen tube growth between medium and high temperatures. We observed comparable pollen germination and tube growth at medium and high temperature, irrespective of cultivar (Table 1). At medium and high temperature regimes, pollen tubes had reached the base of the style or grown beyond by 48 HR post pollination, again, irrespective of cultivar. Hand pollinations were made also in the field and samples were collected at similar intervals. These samples are being analyzed currently for comparison with growth chamber results – preliminary sampling shows pollen tube growth to the base of styles in every cultivar by 24 HR post pollination.

Table 1. Effects of temperature on pollen germination and pollen tube growth rate in four model cultivars. Pollinations were manual with NY54 (S_2S_6). L = 38/50F day/night; M = 8/18F; H = 12/24F. 0 – no pollen germination; 1 – germination but no penetration of style; 2 – pollen tube growth to ¼ way to stylar base; 3 – halfway to stylar base; 4 – three quarters way to stylar base; and 5 – to or beyond stylar base

Hours post pollination	Bing			Benton			Regina			Sweetheart		
	L	M	H	L	M	H	L	M	H	L	M	H
2	0	0	0	0	0	0	0	0	0	0	0	1
4	0	0	0	0	1	1	0	0	1	0	1	1
8	0	1	2	0	1	2	0	2	2	0	3	2
24	0	3	3	1	2	3	0	2	3	0	3	3
32	2	4	4	2	4	4	3	4	4	2	4	4
48	3	5	5	4	5	5	5	5	5	3		
72	4	being analyzed										
96	being analyzed											

In 2009 we collaborated with Dr. Dave Rudell to assess flower nectar quantity and quality of our four model cultivars. It was hypothesized that variability in pollinator activity, vis-à-vis nectar reward, might account for differences in fruit set among cultivars. 'Regina' flowers had the greatest volume of nectar volume whether sampled from the field or the controlled environment chamber. 'Benton' and 'Bing' were similar, and 'Sweetheart' flowers had the smallest volume. Qualitatively there were no significant differences. Analysis showed that sucrose accounted for ca. 50% of nectar sugar weight in all varieties. 'Regina' and 'Benton' have more fructose and glucose than 'Bing' and 'Sweetheart', and no difference in sorbitol concentration was observed among four cultivars. From this preliminary investigation it appears that floral nectar quantity and quality do not account for differences in natural fruit set. However, we believe the role of pollinators should be investigated further, in relation to flower nectar and pollen reward.

We took the best performers from our PGR trials in 2008 and repeated trials in 2009. Treatments were made to 'Bing', 'Tieton', 'PC8011-3', and 'Regina' trees to improve fruit set. 'Bing' flowers treated with 4-chlorophenoxyacetic acid (CPA, 30 ppm) exhibited 70 – 100% higher fruit set than untreated in both small (i.e., limb) and large (i.e., whole-tree) trials. This treatment also improved fruit size by ca. 10% over untreated trees. We are particularly interested in further trials with CPA and have initiated trials in Tasmania on 'Regina' and 'Kordia'. Most of the cytokinins tested had no effect on fruit set though CPPU-treated trees had 10 – 25% greater set than untreated. Interestingly, another cytokinin, Topolin exhibited efficacy as a thinner, reducing fruit set by about 10 – 20%. Of the gibberellins tested, GA_1 was ineffective while GA_3 + GA_{4+7} increased fruit set by 30 – 50%. In 'Tieton' both CPA and GA_{4+7} significantly increase fruit set but the latter led to greater improvements in fruit size and is recommended for further testing. We also tested polyamines (e.g., putrescine, spermine) and Harvista (1-MCP, in collaboration with Dr. Dana Faubion) in 'Tieton' and 'Regina'. In 'Tieton', fruit set was increased by 8% compared to control but we found no improvements in 'Regina' fruit set. Natural fruit set in 'Regina' in 2009 was about 4% - likely related to rapid ovule senescence in during warm weather. Flower samples were collected post-application for assessment of pollen tube growth. No PGR treatment increased growth rate of pollen tubes. This suggests that improvements in fruit set may have been due to extending the viability of the ovules (an approach that we intend to pursue for improving fruit set). In our current proposal, we outline large-scale field trials with the most promising treatments. If successful, we may be able to partially overcome the low fruit set/crop load issue with certain cultivars.

In 2009 we followed up limb trials from 2008 with whole-tree applications of the most promising PGR treatments for fruit quality. Combinations of Apogee (PCa) and gibberellins were effective at improving quality of 'Bing' when applied 30 or 37 days after full bloom. Analyses of fruit weight distribution showed that, the percent of fruit that were 9-row and larger was ca. 20%, 37%, and 80% for control, PCa + $GA_{4/7}$, and PCa + GA_3, respectively (Figure 6). In addition, both first and second spray of PCa alone resulted in a 15% increase in the ≤ 9 row size category than the control. Further analyses of fruit yield vs. fruit size relationships from plotting crop yield/tree vs. yield of premium size class fruit (≤ 9 row) showed that both PCa+ GA_3 and PCa + $GA_{4/7}$ treatments have potential to improve crop yield and fruit size in 'Bing' sweet cherry (data not shown).

The ability of two ostensibly counteracting PGRs to affect fruit quality as reported herein is intriguing, and worthy of further investigation. Prohexadione-Ca (PCa), is an inhibitor of GA biosynthesis, that can reduce vegetative extension growth in apple and sweet cherry (Elfving et al, 2005). We hypothesized initially that we could improve fruit quality by reducing competition between vegetative sinks and fruit growth with PCa applications during rapid shoot growth. Our results of shoot growth (data not shown) show significant reductions in shoot growth rate beginning ca. 2 weeks after application. The benefits from combinations of GA and PCa are greater than from PCa alone. We attribute this to the additional benefit of increasing sink strength of the fruit and therefore, improved canopy source-sink relations to allow greater carbon partitioning to fruit growth. PCa + GA treatments are being tested in Tasmania in large-scale field trials in the current season. Results will inform efficacy in another environment/season and on additional cultivars ('Regina' and 'Sweetheart') for further testing in WA for 2010.

A separate trial studied the incidence of sweet cherry flowers with protruding pistils (i.e., stigma and portion of style extended beyond the unopened corolla) and whether fruit set was affected by this condition (Fig. 1). In 2008 we observed significant incidence under field conditions. In 2009 we recorded the incidence in 19 cultivars, fruit set of flowers with protruding pistils, and studied the role of temperature on incidence and floral organ characteristics in growth chambers. The natural incidence of protruding pistil flowers in 2009 varied from 0% to ca. 23%. 'Sweetheart' (11%), 'Lapins' (23%), and 'Rainer' (9%) had the highest percentage of flowers with protruding pistil flowers. We did not observe protruding pistils in 'Olympus', 'Attika', 'Chelan', 'Blackgold', 'Regina', 'Selah', or 'Benton' flowers. Interestingly, our investigations of fruit set showed that flowers with prematurely exposed stigmas had similar fruit set potential to normal flowers. Growth chamber studies revealed the incidence of flowers with protruding pistils flowers is greater at low temperatures. Flowers opening in Low temperature treatment induced the formulation of stigma exsertion, and ‘Sweetheart’ (14%) and ‘Regina’ (21%) had higher ratio of stigma exertion than ‘Bing’ (1%) and ‘Benton (0%)’. The length of the exposed stylar varied among cultivars from 0.02 mm to 2.5 mm among cultivars, and ‘Sweetheart’ and ‘Lapins’ have the longest ones.This is likely due to growth of petals and pedicels being more sensitive to cold temperature than pistil growth. Low temperature (2/10℃ day/night) reduced petal size but not stylar length. However, after the flowers open, the anthers were sufficiently long to reach or extend beyond the stigma in most cultivars and be suitable for pollination by bees visiting, which indicates that the cherry flowers have a compensation mechanism in the reproductive process for the achievement of pollination and set fruit under adverse weather conditions.

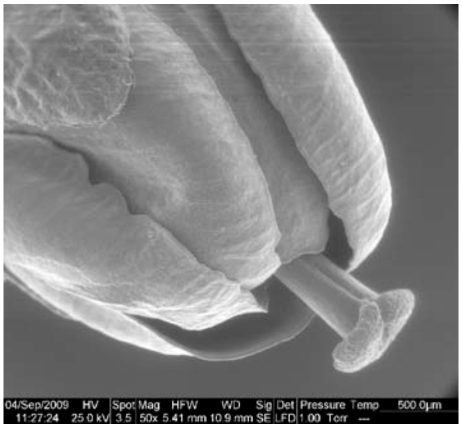


Figure 1. Scanning electron micrograph of flower with a protruding pistil.

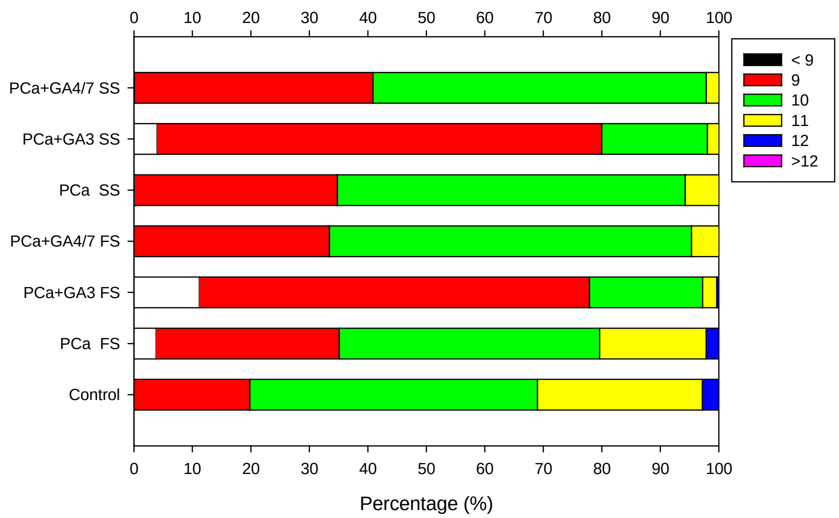


Fig. 6 Effect of PCa and GA isomers (GA_3, $GA_{4/7}$) alone or theire combination applied at 30 (first spray, FS) and 37 (second spray, SS) days after anthesis on cherries fruit row size distribution of 'Bing'., 2009.

CROP LOAD MANAGEMENT

Trials in 2009 addressed bloom thinning, post-bloom thinning, timing of thinning, and a novel approach for delivery of hormone treatments to developing fruit. We continued investigating the potential for post-bloom thinning of sweet cherry in 2009. Overall, our attempts to induce premature abscission of fruit were unsuccessful. No treatment reduced fruit set compared to unthinned control (Table 2). Each thinner was applied at 14 and 21 days after full bloom. Lack of thinning may be due to the ineffective of hormones tested, timing, or rate. We conducted a pilot study to develop a method for delivery of hormones to abscission zones in situ, using hormone solutions and thread. This method shows promise and will be pursued in the future and a means of screening hormones for their effect on fruit abscission. The challenge of inducing abscission in pollinated, developing fruit is novel for sweet cherry (perhaps stone fruit in general) and will require concurrent and complementary avenues of research.

Table 2. Thinning efficacy of 6-benzyladenine (BA), ethephon, and naphthalene acetic acid (NAA) applied at either 14 or 21 days after full bloom to 12-year-old ‘Bing’/’Gisela®5’ sweet cherry trees.

Treatment	Fruit set (%)	
	14 DAFB	21 DAFB
Control	22%	31%
BA	29%	32%
Ethephon	27%	25%
NAA	34%	34%

In a separate post-bloom thinning trial with ‘Bing’, we tested ABA, BA, NAA, and Topolin. Each PGR was applied alone and in combination with PCa at 30 days after anthesis. PCa + NAA and PCa + ABA showed efficacy potential for bloom thinning with fruit set being ca. 56%, compared to 85%

for untreated control. These results suggest that timing of application is important since earlier applications of NAA were ineffective. We hope to pursue these combinations at more timings to better understand the timing vs. efficacy relationship. Interestingly, PCa + BA exhibited potential for increasing fruit size (treated fruit were 20% larger than untreated) without decreasing in fruit set – another treatment worthy of further, larger scale testing.

We also studied the role of timing of thinning on fruit quality and yield in ‘Bing’ and ‘Sweetheart’. On each thinning date, the entire crop was reduced by 50% by removing half of the flowers/fruit on every spur. Regardless of timing of thinning, fruit yield was reduced, however, not all thinning timings improved fruit quality. It appears that thinning at full bloom is significantly better than later thinning (Fig. 2), irrespective of cultivar. Thinning at straw and later (i.e., during stage III) did not improve fruit quality in either cultivar, despite significant reductions in yield. Recent research has highlighted the importance of mesocarp cell size (i.e., stage III of fruit development) in final fruit size, diminishing the role of cell number (i.e., stage I of fruit development). The current data contradicts this by showing greater benefits to fruit size with earlier thinning. Earlier thinning also improved soluble solids compared to later thinning and unthinned fruit. Firmness was not affected. Further, fruit from trees thinned at full bloom were subtly advanced in maturity (ca. 2 days), based on fruit exocarp color data (not shown).

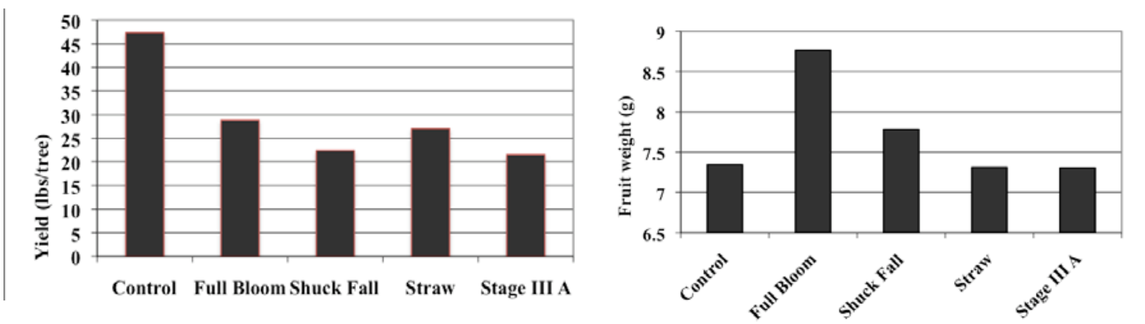


Figure 2. The effect of timing of thinning to 50% natural fruit density on fruit yield and weight of ‘Bing’ and ‘Sweetheart’ trees.

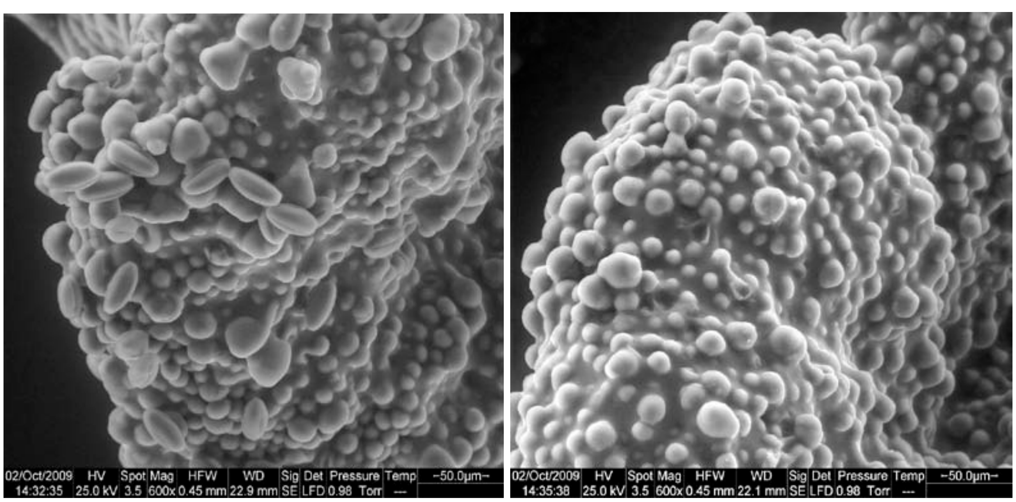


Figure 3. Scanning electron micrographs of portions of ‘Sweetheart’ stigmas (600x) captured at Central Science Lab, University of Tasmania. A – treated with 2% ATS; B – untreated. Images were captured 4 hr after application from recently opened flowers.

Previous work in our lab documented significant variability in individual fruit quality among fruit within a limb, and spur (data not shown). We recorded greater than two-fold variation in fruit weight and firmness among fruit on a spur and hypothesized that these differences were due to date of anthesis/pollination. In 2009 we flagged individual flowers on their day of anthesis (i.e., accessible to bee) and evaluated fruit quality individually at commercial harvest maturity. There is a clear negative relationship between day of anthesis and fruit quality potential (Fig. 4). This preliminary result suggests that effort should be made to pollinate the early-opening flowers to maximize fruit quality. It may be prudent to eliminate late-blooming flowers with chemical means, or remove pollinators from the orchard early (i.e., before full bloom).

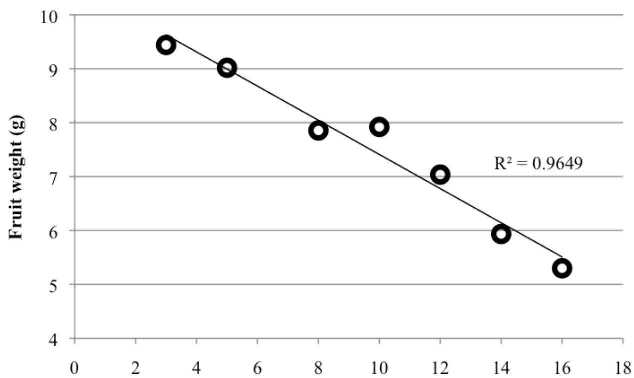


Figure 4. Relationship between mean final fruit weight at commercial harvest and relative day of anthesis in 'Bing'.

In 2009, we began assessments of stigmatic anatomy over time, in relation to receptivity, using scanning electron microscopy. Two lines of research were undertaken in 2009, both in Tasmania and in Washington. First, observations of stigmatic surface ultrastructure were made over time, on flowers marked for their day of anthesis. Flowers were harvested and assessed at 24 hour intervals post-anthesis. Second, we collected flowers within 4 hours of 2% ATS application to assess the effects of this thinner on stigma structure and receptivity. We observed maximum stigmatic exudate (and presumably receptivity – to be confirmed) just prior to anthesis/first opening, irrespective of cultivar. There were no apparent anatomical differences between cultivars with high fruit set and low fruit set (e.g., 'Sweetheart' vs. 'Regina'). Interestingly, flowers treated with ATS were structurally similar to those untreated but had significantly more pollen adhered to the stigmatic surface (Fig. 3). It appears that the airblast application has inadvertantly transferred pollen to the stigma. This preliminary finding of pollen transfer during chemical bloom thinning suggests that thinning applications in self-fertile cultivars may not be as effective as in self-sterile. In reviewing previous chemical bloom thinning trials, we found that we typically under-thinned self-fertile cultivars. This hypothesis is one we propose to test further.

Field and growth chamber studies of ovule longevity and stigma receptivity supported our previous season's findings. 'Benton' and 'Bing' had the longest ovule viability compared to 'Regina' and 'Sweetheart'. Stigmatic receptivity, as evaluated the by perex test, was high in 'Regina' so it appears that rapid ovule senescence contributes to poor fruit set in 'Regina'. We propose to investigate use of PGRs to extend ovule longevity and increase fruit set.

SENSORY STUDIES

Consumer firmness evaluation of three cherry firmness groups

In 2009 our studies of sweet cherry fruit quality were focused on consumers' perceptions and preferences for fruit firmness. Using a Firmtech we evaluated firmness of > 1000 individual fruit. We used these data to develop cherry firmness groupings. This approach was followed for two cultivars, grown commercially, 'Chelan' and 'Bing'. For 'Chelan', low firmness corresponded to a firmness value of <225 g/mm (>20th percentile), intermediate to a value of 240-275 g/mm (40-60th percentile) and high firmness to a value of >290g/mm (<80th percentile). For 'Bing', low, intermediate and high corresponded to firmness values of <169 (20th percentile), 189-198 (40-60th percentile) and >219 g/mm (80th percentile), respectively. These values were similar to those reported in the previous year for 'Selah' cherries. Consumers were presented with cherry samples from two firmness groupings and asked whether there was a difference in firmness between them and which sample they preferred the firmness of (Figure 5).

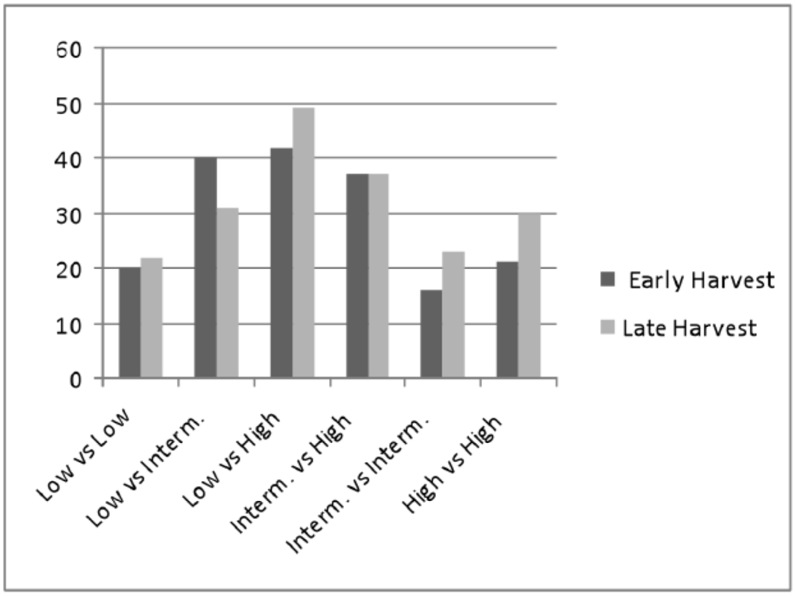


Figure 5. Consumer evaluation of 'Chelan' (early harvest) and 'Bing' (late harvest) cherries of different firmness levels (n= 65). Data are presented as frequency of selection for the analytically firmer sample using a directional paired comparison test. The test was a non-forced choice test, with the question "Which sample is firmer?"

Results showed no significant differences in firmness between cherries from the same firmness grouping. For both cultivars, no significant differences in firmness were found when intermediate firmness cherries were compared to high firmness cherries. Further, for both cultivars, significant differences in firmness were perceived when comparing the low and high cherry firmness groupings, however this did not exceed 50% at any time. When comparing low to intermediate firmness cherries, significant differences were observed for 'Chelan' but these groupings were not significantly distinguished in 'Bing'.

Consumer firmness evaluation of cherries of specific firmness levels

The influence of the acceptance of appearance, firmness, flavor and juiciness on overall acceptance was examined also (Table 3).

Table 3. ANOVA table of the influence of appearance, flavor, firmness and juiciness acceptance on the overall acceptability of early and late harvest cherries.

Attribute	df	F	p-value
Appearance	6	3.99	0.001
Flavor	6	211.72	<0.0001
Firmness	6	33.30	<0.0001
Juiciness	6	37.6	<0.0001

Results indicated that the acceptance of the four individual attributes (appearance, flavor, firmness and juiciness) significantly influenced overall acceptance of the cherries. Of these attributes, appearance had less of an impact on overall acceptance compared to the other attributes while flavor acceptance had a greater impact on overall acceptance. The influence of the analytical measurement of firmness and cultivar ('Chelan' vs. 'Bing') on cherry acceptance was evaluated also (Table 4). Cultivar had a significant impact on the acceptance of firmness and juiciness. Analytical firmness, as measured using the FirmTech, significantly impacted the acceptance of firmness, appearance, juiciness and overall acceptance of the cherries.

Table 4. ANOVA table showing the influence of cultivar and analytical firmness evaluation on the acceptance of firmness, appearance, flavor, juiciness and overall acceptance. The p-value indicates the strength of influence of that particular attribute with * indicating significance at p<0.001.

	Sensory Attribute				
Attribute	Firmness	Appearance	Flavor	Juiciness	Overall Acceptance
Cultivar	0.0018*	0.1229	0.4230	0.0066*	0.3180
Analytical Firmness	0.0000*	0.0063*	0.3301	0.0064*	0.0004*

In examining the specific differences between harvest times, firmness and juiciness acceptance were significantly higher in ‘Chelan’ cherries compared to ‘Bing’ (Table 4). Even though the acceptance of these texture attributes was significantly higher in ‘Chelan’ cherries, there was no significant difference in the overall acceptance of the cherries when compared to ‘Bing’.

Table 4. Mean values of overall acceptance and sensory acceptance of firmness, appearance, flavor and juiciness. All attributes were evaluated along a 7-pt acceptance scale. Significant differences ($p<0.0001$) between harvest times are indicated by *.

	Firmness	Appearance	Flavor	Juiciness	Overall Acceptance
‘Chelan’	5.86*	6.14	5.67	6.07*	5.78
‘Bing’	4.64	5.82	5.53	5.69	5.46

EXECUTIVE SUMMARY

This research and outreach program has achieved, over three years, what it set out to do. Towards developing high efficiency orchard systems that are well-suited to mechanization and automation, we have worked with industry in the creation of a novel training system, the UFO. This training system, designed for creating upright or angled fruiting walls, has been planted and tested throughout the Northwest, and preliminary results are encouraging. We have partnered fully with growers in the development and evaluation of the system – many of the training principles originated from grower innovations. Summer and dormant tours of grower-collaborator orchards have successfully engaged the industry and been effective outreach models. The UFO system is now being planted around the world and included in national training system trials. Further, research funding orchard systems research and mechanical harvest was critical to a successful proposal to the USDA Specialty Crop Research Initiative. We leveraged WA/OR funding into a 4-year, $3.9 million project.

Our research into fruit set and pollination has taken a systematic approach to investigating the role of key factors affecting fruit set:

1. pollen viability
2. pollen growth rates
3. pollinator activity
4. stigma receptivity
5. ovule longevity

Our work has implicated maternal factors as causal to low fruit set. Items 1 & 2 do not appear to limit fruit set in sweet cherry. There is little reason that pollinator activity should limit fruit set as long as hives are available for hire (unless we experience an unusually cold spring and bee flight is negligible). In short, the work over the past few years has yielded new information on factors limiting yield and revealed several promising new avenues for research. Further, we have good preliminary data that can be used for better understanding effective pollination period in sweet cherry, and the role of temperature. Knowing that low fruit set is caused by maternal factors (i.e., stigma receptivity, ovule longevity) rather than by pollen related steps informs the development of potential ameliorative programs. However, it appears that low fruit set may be due to either poor stigma receptivity (‘Benton’) or rapid ovule senescence (‘Regina’). Pollen race trials showed similar fruit set potential whether a cross is “fully” compatible (i.e., both S alleles are distinct from the maternal cultivar) or “partially” compatible (i.e., only one of the two S alleles is compatible). However, we recorded significantly lower fruit set in self-fertile cultivars when using self pollen vs. foreign pollen. We also showed that wind has a negative effect on fruit set. Field trials proved that even low velocity wind reduced fruit set more than high temperature. We’ve also evaluated many PGRs for their ability to affect fruit set (increase or decrease). Several promising programs are recommended for larger scale trials.

Crop load management trials studied potential to balance fruit number with whole-tree carbon supplies throughout the 15-month fruiting timeline. Trials with gibberellins showed that fruit bud initiation can be reduced in a rate-dependent manner when applied at early straw. This approach may have application for late-maturing, highly productive cultivars where harvest delay with higher rates of GA may also be beneficial. The most consistent blossom thinning program evaluated is ATS at 2%, applied at both 20% and 80% of full bloom. Our research has now begun revealing ATS mode of action to develop more effective protocols. Thinning efficacy is greatest on open, unpollinated flowers. This research has helped focus questions for further research. In this project we have also begun testing efficacy of various PGRs as post-bloom thinners. We’ve evaluated caustics and hormonal thinners and developed a method for more targeted screening of potential thinners. Further, we have begun to understand the optimum timing for thinning in sweet cherry by thinning whole trees at key fruit growth stages and evaluating fruit yield and quality relationships. This work has shown benefits to early thinning vs. late thinning and therefore, the importance of reducing competition among fruit for carbohydrate resources in early stages of development. This has prompted us to rethink the relative importance of mesocarp cell number and size in determining final fruit size – we intend to study seasonal cell division and expansion cycles in a new proposal. Lastly, we have shown the ability to manipulate canopy source-sink relations and improve fruit quality with timely application of PGRs. We recommend larger trials of PCa (150 ppm) plus GA_3 (30 ppm) at ca 30 days after full bloom. Perhaps as important as the results from individual experiments, we have evolved the process of fruit set/crop load management investigation. The work reported herein has focused the questions for further, integrative study of yield and quality components in sweet cherry (e.g., bud/flower hierarchy, timing of flowering, mechanical pollination, thinner mode of action, flower populations, etc.).

Our investigations into consumers' preference for sweet cherry attributes and the potential for assigning cultivars to flavor groupings has helped redefine what fruit 'quality' is. This research has underscored the importance of overall flavor, and sweetness in particular, while revealing an inability of consumers (and trained panelists) to discern firmness differences during consumption. For example, only 40% of consumers polled detected a difference in firmness between samples that were < 225 g/mm and > 290 g/mm. Despite their difficulty reconciling different gradations of firmness measure by the Firmtech, consumers do rate fruit firmness and juiciness as important towards eating quality of the fruit.