

## SWEET CHERRY BREEDING AT WASHINGTON STATE UNIVERSITY

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### **Abstract**

Sweet cherry (*Prunus avium*) breeding at IAREC/WSU was begun nearly 50 years ago. During that time, 'Rainier' and 'Chinook' were bred and released by Harold Fogle, and 'Chelan', 'Glacier', 'Olympus', 'Index', 'Cashmere', and 'Simcoe' were bred by Tom Toyama and released by Ed Proebsting. Of these, the blushed yellow 'Rainier' has become the highest valued cherry produced in the Pacific Northwest U.S. and is the premier export cherry destined for Asian markets and major U.S. cities. 'Chelan' is the earliest high quality dark red cherry currently being planted to diversify the ripening window around the industry standard cultivar, 'Bing'. 'Glacier' (a very large-fruited variety), as well as 'Cashmere' and 'Index' (two early-ripening varieties), are the first self-fertile cherries released from IAREC/WSU.

Further selection of Toyama's crosses and new hybridizations are on-going under current lead scientist Greg Lang. The contemporary breeding objectives are to: 1) develop large, very firm dark red and blushed yellow cherries with good sweet/tart flavor suitable for international export; 2) continue to broaden the ripening window, with particular emphasis on early season harvest; 3) incorporate genes for self-fertility and/or resistance to powdery mildew, *Podosphaera clandestina*, into new varieties; and 4) select late blooming cultivars to reduce potential damage by spring frosts.

Key characteristics of the most recent cultivar releases and "elite" selections will be described, including characteristics of possible importance for use on precocious rootstocks. Technical progress in screening and rapid selection for specific traits, such as powdery mildew resistance, will be presented and discussed.

### **1. Introduction**

In 1997, 81,721 tonnes of sweet cherries were produced on 7,700 ha in Washington state, nearly 50% of the U.S. sweet cherry production (Anon., 1998). Approximately 75% of this production is destined for fresh market sales. The primary sweet cherry cultivar is 'Bing', a large, firm, high quality cherry that originated in 1875 as a chance seedling of 'Republican' in Oregon's Willamette river valley (Bargioni *et al.*, 1996). A diverse *Prunus* breeding program began at Washington State University (WSU) in 1949, originally under the administration of the U.S. Department of Agriculture (USDA). Dr. Harold Fogle was the first *Prunus* breeder, whose most important new cherry cultivars were 'Rainier' (selected in 1954 as 'P 1-680'), and 'Chinook' (selected in 1954 as 'P 1-246'); both were released to growers in 1960. 'Rainier' is a precocious, widely-adapted cherry with very large, very sweet fruit having clear yellow flesh and a red-blushed yellow skin. 'Rainier' is now the highest valued cherry produced in the

Pacific Northwest U.S., due to its acceptance as the premier fresh market cherry for export to Asian and major U.S. urban markets. The susceptibility of 'Chinook' to rain-induced cracking has prevented it from commercially impacting Pacific Northwest U.S. cherry production.

Research in the program was continued by WSU scientist Tom Toyama, who conducted active hybridizations from 1960 to 1980, and by WSU physiologist Ed Proebsting, who continued evaluations from the mid-1980s to the early 1990s. Their efforts culminated in the release of six new sweet cherries: 'Chelan', 'Index', 'Cashmere', 'Glacier', 'Olympus', and 'Simcoe'. In 1994, WSU pomologist Gregory Lang succeeded Dr. Proebsting in continuing selection of Dr. Toyama's crosses. 'Tieton', a new sweet cherry from Toyama's advanced selections, was named and released in 1998. New hybridizations were also resumed, along with study of important genetic traits, such as powdery mildew (*Podosphaera clandestina* [Wallr.:Fr.] Lev.) resistance, that are found in the extensive WSU sweet cherry breeding population. The primary selection criteria currently being pursued in the WSU sweet cherry improvement program include: (1) develop large, very firm dark red and blushed yellow cherries with good sweet/tart flavor suitable for international export; (2) continue to broaden the ripening window, with particular emphasis on early season harvest; (3) incorporate genes for self-fertility and/or resistance to powdery mildew into new varieties; and (4) select late blooming cultivars to reduce potential damage by spring frosts.

## 2. New WSU cherry cultivars

The ripening sequence, and average fruit size relative to 'Bing', of various WSU cultivar releases and "elite" selections is depicted in Figure 1.

### 2.1. 'Chelan'

'Chelan' was selected as 'PC 7146-23' from a cross of 'Stella' x 'Beaulieu'. Of the recent WSU cherry cultivars released, it has been adopted by U.S. cherry growers to the greatest extent thus far (>100,000 trees planted in 1998 alone). 'Chelan' is a moderately large, dark red, high quality cherry, similar in appearance and productivity to 'Bing', yet it ripens 10 to 14 days earlier. 'Chelan' begins cropping earlier than 'Bing', being similar to 'Rainier' in precocity. Thus, precocious, or yield-enhancing rootstocks are not necessary for early cropping or high yields with 'Chelan'.

'Chelan' is not self-fertile, and its pollen compatibility grouping has not yet been classified. It begins blooming several days ahead of 'Bing', but it produces a large quantity of flowers over a long bloom period that generally overlaps sufficiently with 'Index', 'Van', 'Rainier', 'Lapins', and/or 'Bing' to provide sufficient pollination. Significantly, 'Chelan' has exhibited among the lowest levels of rain-cracked fruit in WSU and grower test plots (averaging about 10% cracked fruit when 'Bing' fruit was 30% or more cracked).

### 2.2. 'Cashmere'

'Cashmere' was selected as 'PC 7144-3' from a cross of 'Stella' x 'Early Burlat'. It is a moderately large, dark red, 'Bing'-like cherry that ripens 8 to 11 days earlier than 'Bing'. 'Cashmere' is self-fertile, blooms several days after 'Bing', and appears to have very good cold hardiness, contributing to a consistent cropping history in the evaluation orchard. The growth habit of 'Cashmere' is quite open and spreading. The main drawback of 'Cashmere' is a tendency for fruit to raincrack to a greater degree than 'Bing'. If reliable rain-cracking protection strategies (such as raincovers or overhead calcium sprinklers) become common, 'Cashmere' has many important traits (early ripening, late-blooming, self-fertile, cold hardy, desirable growth habit) for future consideration.

### **2.3. 'Tieton'**

'Tieton' was selected as 'PC 7144-6' from a cross of 'Stella' x 'Early Burlat'. Released in 1998, 'Tieton' is a very large, dark glossy red, high quality, mild-flavored cherry similar to 'Bing', but ripening 6 to 9 days earlier. The extraordinary size (10 to 14 g, 28 to 32 mm in width) of 'Tieton' fruit, combined with export-quality firmness and early ripening date, make it a cherry with very high potential for premium markets. It has an early-to-mid bloom period (similar to 'Bing'), is not self-fertile, and its pollen compatibility grouping has not yet been classified. Its susceptibility to rain-cracking is similar to that of 'Bing'.

'Tieton' generally produces flowers in clusters of 2 to 3, resulting in light crops when pollination is limiting. Current research is testing the hypothesis that genetically moderately-yielding cultivars such as 'Tieton' may produce optimal crop loads on new highly-productive, vigor-controlling rootstocks (such as 'Gisela 5' or 'Edabriz') that otherwise can overset crops (Lang and Ophardt, 1999) typical with high yielding cultivars such as 'Bing' or 'Rainier'.

### **2.4. 'Simcoe'**

'Simcoe' was selected as 'PC 7147-1' from a cross of 'Stella' x ('Hollander' or 'Starking Hardy Giant'). It is a large, heart-shaped, dark red cherry that ripens in the early season, 6 to 8 days ahead of 'Bing'. It blooms slightly late, is not self-fertile, and tends to crop well. The pollen compatibility grouping for 'Simcoe' has not yet been classified. It has good firmness and acidity, and a lower tendency for rain-cracking than 'Bing'. 'Simcoe' trees are vigorous and spreading in habit. To date, it has been released primarily in France.

### **2.5. 'Index'**

'Index' was selected as 'PC 7222-1' from a cross of 'Stella' x unknown. It is a large, dark red cherry similar to 'Bing', with a glossy skin, somewhat flattened suture side of the fruit, and high eating quality. 'Index' ripens 4 to 6 days earlier than 'Bing' and tends to be similar in both productivity and rain-cracking susceptibility. It is self-fertile and blooms early. 'Index' has been among the highest ranked selections for overall fruit quality and productivity in evaluation plots at Cornell University in Geneva, New York (B. Andersen, personal communication).

### **2.6. 'Glacier'**

'Glacier' was selected as 'PC 7144-7' from a cross of 'Stella' x 'Early Burlat'. It is a very large, dark red, high quality cherry that is considered to be too soft for commercial shipping to distant markets. 'Glacier' ripens 1 to 3 days ahead of 'Bing' and produces a good crop of flavorful, exceptionally large fruit (15 to 16 g and 33 mm in width is not uncommon). 'Glacier' is self-fertile and blooms relatively late; therefore, it may be an ideal cultivar for local markets and home gardens, especially when combined with dwarfing rootstocks.

### **2.7. 'Olympus'**

'Olympus' was selected as 'PC 6659-2' from a cross of 'Lambert' x 'Van'. It is a heart-shaped, large, dark red cherry that ripens 4 to 6 days after 'Bing', just ahead of 'Lapins'. It is not self-fertile, but blooms late and generally crops very well. The pollen compatibility grouping of 'Olympus' has not yet been classified. 'Olympus' was released as a superior alternative to 'Lambert'.

### **3. Recent WSU cherry selections advanced to “elite” testing status**

#### **3.1. ‘PC 8007-2’**

‘PC 8007-2’, a cross of ‘Glacier’ x ‘Cashmere’, is a very large (10-11 g), very flavorful early-ripening cherry. The roundish-shaped fruits reach maturity just after ‘Chelan’, but are much larger and generally have higher soluble solids. ‘PC 8007-2’ is not self-fertile and is late-blooming; the pollen compatibility grouping and suitable pollenizers have yet to be determined.

#### **3.2. ‘PC 8011-3’**

‘PC 8011-3’, a cross of ‘PC 7147-4’ x ‘PC 66138-2’, is a very large (10-12 g), very high quality ‘Rainier’-type yellow cherry with very high soluble solids and an excellent reddish blush. ‘PC 8011-3’ ripens nearly a week ahead of ‘Rainier’, thus providing an excellent complement to ‘Rainier’ production in the Pacific Northwest U.S. It is not self-fertile, and both the pollen compatibility grouping and suitable pollenizers have yet to be determined. ‘PC 8011-3’ is among the latest-blooming selections at WSU/IAREC, more than a week later than ‘Bing’ and ‘Rainier’.

#### **3.3. ‘PC 7147-9’**

‘PC 7147-9’, a cross of ‘Stella’ x (‘Hollander’ or ‘Starking Hardy Giant’), is a large (9-11 g), ‘Bing’-like cherry that is the latest ripening of the current WSU/IAREC advanced selections. Maturing later than ‘Lapins’ but earlier than ‘Sweetheart’, it has high quality fruit with both good soluble solids and acidity levels (the latter important for longer late-season shelf-life). It is self-fertile, late-blooming, and productive, and in controlled field bioassays, the fruit have exhibited a significantly low susceptibility to rain-cracking.

### **4. Mildew resistance: an important genetic trait**

#### **4.1. ‘PMR-1’**

Epidemics of powdery mildew on sweet cherry have occurred in Washington production districts in recent years (Grove and Boal, 1991a), with severe financial losses when entire lots of fruit are rejected due to infection (Grove and Boal, 1991b). The fungus overwinters as cleistothecia on the orchard floor, in tree crotches, and in bark crevices (Grove and Boal, 1991a). Rain during April and early May promote ascospore release and primary foliar infection, with secondary infections of foliage continuing over the next 6 to 8 weeks preceding harvest (Grove and Boal, 1991b). Secondary infections are caused by the sporulating primary colonies and subsequently are a source of inoculum for fruit infection.

A potential source of resistance to powdery mildew has been identified in the WSU/IAREC sweet cherry breeding population. A chance seedling, ‘PMR-1’, has been shown to exhibit an immune reaction to foliar infection by powdery mildew (Toyama *et al.*, 1993). Although ‘PMR-1’ fruit quality attributes are generally good, moderate fruit size (7-8 g) precludes its use as a commercial variety in the Pacific Northwest U.S. While the mechanism of ‘PMR-1’ resistance to powdery mildew has yet to be determined, the selection has potential as a gene donor in disease resistance breeding. Preliminary observations of open-pollinated seedlings from ‘PMR-1’ trees show segregation for resistance to natural mildew spread under greenhouse conditions, suggesting the trait is heritable.

## **4.2. Mildew screening procedures**

Current research at WSU/IAREC involves the development of detached leaf culture screening procedures and a powdery mildew rating scale for sweet cherries. Detached leaf culture has been used successfully for powdery mildew screening in other horticultural crops (Fanourakis, 1990), with the advantages of being performed quickly, requiring minimal space, and providing results early in the life cycle of seedlings. We have conducted preliminary experiments to optimize germination of powdery mildew conidia on detached leaves, examining the effects of photoperiod, leaf age, leaf portion size, and growth substrate nutrient composition. The abaxial sides of various sized detached leaf disks were inoculated artificially (Grove and Boal 1991b), and cultured in petri dishes (150x10mm) on either an aqueous layer or moist filter paper to maintain high relative humidity. Optimum mildew growth was found to occur at 22° C on young, emergent but unexpanded leaves. A 14:10 hr light:dark photoperiod and 1% sucrose aqueous solution supported the best mildew growth. No significant differences in mildew growth were found between leaf portion sizes, therefore 30 mm disks were used for all subsequent assays.

In establishing disease rating scales, visual assessment of infection percentages can be hard to estimate accurately (Sherwood *et al.*, 1983). The use of computers can aid in disease assessment (Lindow, 1983). We are now using a computer graphics program (SigmaScanPro ver. 4.0, SPSS Scientific, Chicago, IL) to quantify the percentage diseased area of the cherry leaf cultures described above. At 14 days after inoculation, images of the detached leaves are scanned into a standard desktop computer using a flatbed color scanner (Scanmaker E6, Microtek Lab, Redondo Beach, CA). The diseased portions are assigned a color value separate from healthy tissue (Figure 2), and the percentage diseased area is quantified on a pixel by pixel basis. These measurements are being used to develop standard area diagrams (James, 1971) for subsequent use in rapid screening of breeding selections for powdery mildew resistance. Similar screening of a variety of commercial cultivars is also ongoing to identify sources of powdery mildew tolerance or resistance other than 'PMR-1'.

## **4.3. Inheritance of mildew resistance**

Reciprocal crosses between 'PMR-1' and the commercial varieties 'Bing', 'Van', and 'Rainier' were made in the spring of 1998. Seeds have been harvested and placed in stratification. Progeny from these crosses will be evaluated and classified for degree of resistance or susceptibility to powdery mildew during spring 1999 using the standard area diagrams. Resulting variances and segregations will be used to estimate the inheritance of the resistance conferred by 'PMR-1'.

## **5. Conclusions**

Sweet cherry breeding and selection at WSU/IAREC has made an important impact on Washington and U.S. cherry production. 'Rainier' is currently the highest value sweet cherry produced in Washington state, and 'Chelan' has effectively extended the harvest season for early-ripening high quality cherries. The desirable traits of self-fertility and late bloom period have been incorporated into several recent cultivar releases and advanced "elite" selections. Further study of other important genetic traits available in the WSU breeding population, such as powdery mildew resistance, will add to the potential for continued improvement of sweet cherries for production in Washington state and other cherry-growing regions.

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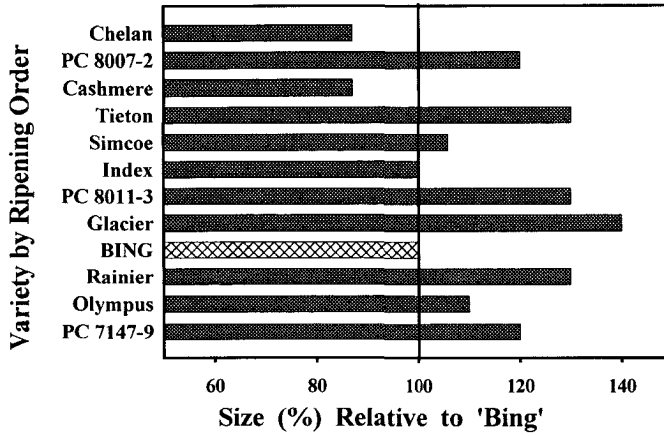
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**Figures**

1. Ripening sequence and average fruit size for different sweet cherry varieties

**Ripening Sequence and Average Fruit Size**



2. Quantification of powdery mildew on detached cherry leaf disk cultures

