Blackberry production in the Pacific northwestern US: a long history and a bright future

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Abstract

The Pacific northwest of the United States has a long history of blackberry production and research. The breeding program began in the 1920s with George Darrow and soon thereafter with George Waldo. They utilized the native species, *Rubus ursinus*, along with 'Logan' in their breeding program to develop the first important commercial cultivars 'Pacific' and 'Cascade' in the 1930s. These two, along with 'Logan', 'Santiam', and the *R. laciniatus* selection 'Evergreen', served as the basis for the trailing blackberry processing industry. Initially fruit was canned and shipped back to the population centers in the eastern US. Freezing to preserve the crop to ship back east became common once the technology for freezing was developed in the 1920s. The breeding programs developed 'Olallie' in the 1940s that became, along with 'Boysen', the major cultivars in California until the blackberries developed by Driscoll Strawberry Assoc. (Watsonville, CA) surpassed them in area in the early 1990s. In 1956, 'Marion' was released and while it took about 10 years for 'Marion', marketed as marionberry, to become popular, it then became the dominant cultivar in the Pacific northwest. The release of 'Marion' in the 1950s and the development of the machine harvester in the 1960s combined with the ideal climate of the Willamette Valley cemented this region's importance for blackberry production. The industry has been challenged by having 90-95% of production sold for processing. However, even with a small percentage of area devoted to fresh, this region is one of the most important also for fresh fruit in the US. Winters with cold, injurious temperatures have led to large fluctuations in production and grower price, making processors reluctant to develop new products. Thorns in the machine-harvested product also have been a challenge that needed to be overcome. 'Black Diamond', a thornless, high yielding, and more cold hardy cultivar helped increase the reliability of a high quality crop. This stable production combined with increased consumer interest has led to a steadily increased production of fruit for processing as well as for the fresh market. A wonderful climate and a determined industry that has supported collaborative cultivar development and horticultural research have been keys to the development of a vibrant blackberry industry in the Pacific northwest.

Keywords: breeding, horticulture, processing, machine-harvest

INTRODUCTION AND HISTORY OF CULTIVAR DEVELOPMENT UNTIL THE 21ST CENTURY

The Pacific northwest, particularly the Willamette Valley in Oregon, has been among the most important areas in the world for blackberry production for over 100 years. Early settlers to the Willamette Valley found a plethora of native berries and they brought fruit plants with them over the Oregon Trail beginning in the mid-1800s. They found fertile soils and a climate that was ideal for berries (Figure 1). The summers are dry with warm days and cool nights that are optimal for outstanding fruit quality. The winters are characterized by 100-115 cm of rain and typically mild minimum temperatures that are seldom below -12°C.

Reviews of the development of blackberry as a crop and their breeding have been written in more detail than is possible here (Clark et al., 2007; Clark and Finn, 2011; Finn and Clark, 2012). A review of blackberry production systems is provided by Strik and Finn (2012).

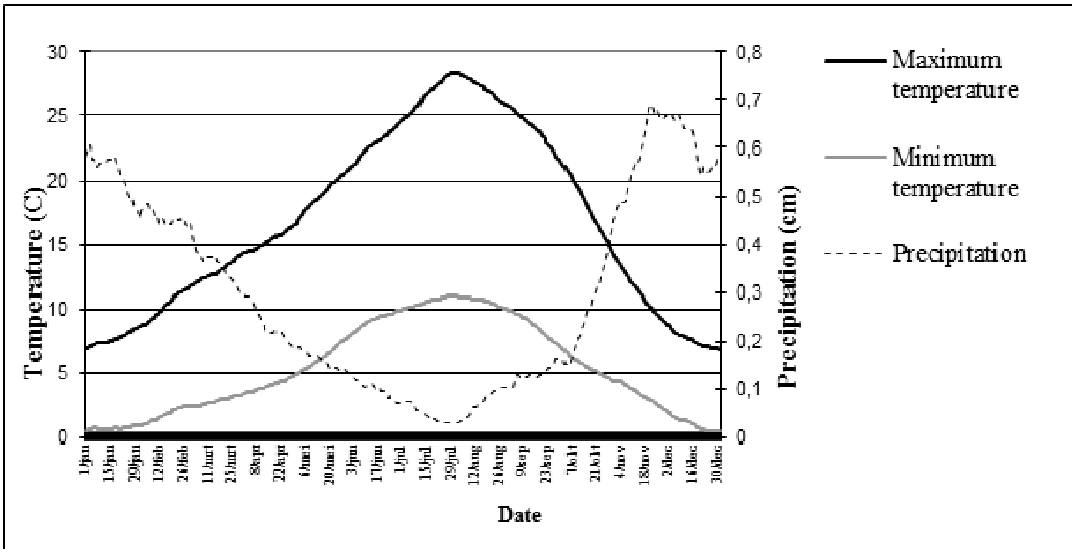

Figure 1. Mean daily maximum and minimum temperatures and precipitation from 1900 to 1990 in Corvallis, OR.

The native blackberry (*Rubus ursinus* Cham. & Schtldl.) was harvested from the wild and Seth Lewelling, developer of the 'Bing' cherry, introduced the 'Lawton' blackberry in the late 1850s. Many Oregonians became wealthy shipping fruit to California by wagon and later by boat until Californians began planting their own berries. Also about this time, the European native 'Evergreen' blackberry (*R. laciniatus* Willd.) was brought from the Hawaiian Islands and it began to naturalize in the region. The next major introduction was the 'Himalaya' blackberry (*R. armeniacus* Focke) around 1885. While *R. armeniacus* has origins in eastern Europe, the 'Himalaya' blackberry is thought to be either the same as, or very similar to, the German 'Theodore Reimers'. 'Evergreen' and 'Himalaya' quickly escaped to the wild and spread vigorously. While 'Evergreen' is not difficult to find in the landscape it is much less common than 'Himalaya' that seems to take over any open ground or fence row in the Willamette Valley. While classified as a noxious weed, 'Himalaya' is often enjoyed as it is part of many families' cultures to go out and pick it from the wild in late summer.

The next important cultivar that helped establish a blackberry industry was the 'Logan' or 'Loganberry'. 'Loganberry' was discovered in 1889 by Judge James Logan in his amateur breeding program in Santa Cruz, CA (Logan, 1909, 1955). The discovery of 'Logan' was a surprise as it was obvious to him that it was out of a cross of 'Red Antwerp' red raspberry and *R. ursinus*, which most did not consider possible. 'Loganberry' was planted in Oregon and became so important that by 1915 the State of Oregon celebrated a "Logan Day" at the Panama Pacific International Exposition. Also, Judge Logan was invited to the Oregon State Fair in 1922 where he was recognized by Oregon's governor for his great contributions to the state (Logan, 1955). 'Loganberry' and 'Evergreen' were harvested for the canning industry from the late 1800s until the advent of freezing technology in the 1920s although Oregon Fruit Products (Salem, OR) still cans a substantial amount of fruit today (Waldo, 1977).

Another important early raspberry × blackberry hybrid was 'Boysen' that was discovered in 1921. While its parentage is unknown, it was suspected to be a hybrid between red raspberry and *R. ursinus* or more probably a 'Loganberry' and a trailing blackberry like 'Lucretia' or 'Austin Mayes' (Wood et al., 1999). By 1935, 'Boysen' was being widely planted and in the late 1930s, there were almost 810 ha in Oregon.

The 1920s and 1930s were important times for the industry and for the breeding program. The industry was growing with its emphasis shifting slowly from canned to frozen as various companies began to develop and optimize the freezing technology that Clarence Birdseye had first developed for freezing fish (Richards, 2012). The berry breeding program

with the Oregon Agricultural Experiment Station was begun in 1911 by V.R. Gardner (later to head the Michigan Agric. Expt. Stat.) and continued by C.E. Schuster (later to head the hazelnut breeding program), but their work was focused on strawberry. George Darrow moved to Oregon from the east in 1927 and began the blackberry and raspberry programs with the USDA in Oregon. After five years, he and George Waldo switched locations with Waldo returning to his Oregon roots and Darrow going back to Beltsville to coordinate the USDA's berry breeding at a national level.

Darrow's work focused on assembling a germplasm collection to use as parents. Most of the selections made in the first 10 years of the breeding effort were from crosses among nine genotypes including: 'Austin Thornless', 'Himalaya', 'Ideal Wild', 'Logan', 'Lucretia', 'Mammoth' ('Black Logan'), 'Santiam' (a hermaphroditic selection from the wild), 'Youngberry', and 'Zielinski' (a superior selection of *R. ursinus*) (Finn, 2001). 'Logan' and 'Zielinski' were by far the most commonly used parents and the first two cultivars released, 'Cascade' and 'Pacific' were selected in 1935 from a cross of these two. In 1938, 'Olallie' ('Black Logan' ['Mammoth'] × 'Young') was selected and then released in 1944. These three cultivars were important in the commercial industry and as parents. 'Olallie' never did as well in Oregon, due to lack of sufficient cold hardiness, as it did in California where it was a significant commercial cultivar until the 1990s. 'Chehalem' ('Santiam' × 'Himalaya') was selected in 1939 and while it had some commercial impact its main claim to fame is being one of the parents, along with 'Olallie' of the iconic 'Marion' blackberry (Waldo, 1957; Finn et al., 1997).

'Marion' was selected in 1948 and released in 1956. While it took about 10 years to get established in the industry it became popular in the late 1960s (Figure 2). The trend in marketing cultivars in the West for a long time was to call everything "XXXberry"; therefore you had loganberry, youngberry, olallieberry, boysenberry, and marionberry. Bob Conroy of Conroy Processing (now part of Townsend Farms, Woodburn, OR) often credited 'Marion's adoption to a sale in the late 1960s of 'Marion' fruit to Bama Pie Company (Tulsa, OK) who did not have enough berries from their usual suppliers and were willing to try 'Marion'. They liked them enough to make them a significant part of their formulation from then on.

'Kotata', grown commercially for decades as "1050", was selected in 1950 and 'Silvan' ('Marion' × OSC 742), selected from seed Waldo sent to Australia in 1952, were other additions to the mix of cultivars grown in Oregon.

Francis "Whitey" Lawrence ran the breeding program from the late 1960s to the late 1980s. He was responsible for naming "1050" as 'Kotata' and more importantly for developing a collection of parents with superior fruit quality traits and that contained the 'Austin Thornless' source of thornlessness. 'Waldo', released in 1985, was the first commercial cultivar with the 'Austin Thornless' source of thornlessness. This source is interesting because while partially dominant, many of the seedlings have thorns on canes up to approximately a height of 20-25 cm. So they are often not truly thornless but they are functionally thornless. Unfortunately, this means they cannot be screened for thornlessness until they have been growing in the field for several weeks. Lawrence also shared a great deal of germplasm, as did the Scottish Crop Research Institute (now James Hutton Inst.) with the nascent New Zealand HortResearch (now the Plant and Food Institute of New Zealand) program in the late 1970s. Harvey Hall as the New Zealand breeder intercrossed the germplasm from these sources and other breeding material that he in turn shared back with the USDA-ARS/Oregon State University in Oregon in the late 1980s and early 1990s. A selection in Oregon by Finn of a cross shared by Hall of a New Zealand selection × 'Kotata', yielded 'Black Diamond' that has become the most important blackberry cultivar being planted in the Northwest (Finn et al., 2005a). In addition to mixing the germplasm in New Zealand, Hall et al. (1986a, b) developed a genetically thornless, versus a thornless chimeral, 'Loganberry' called 'Lincoln Logan'. This source of thornlessness was shared with Oregon and recently resulted in 'Columbia Star', which is the first blackberry, as opposed to 'Boysen'-type, cultivar with this source of thornlessness (Finn et al., 2014).

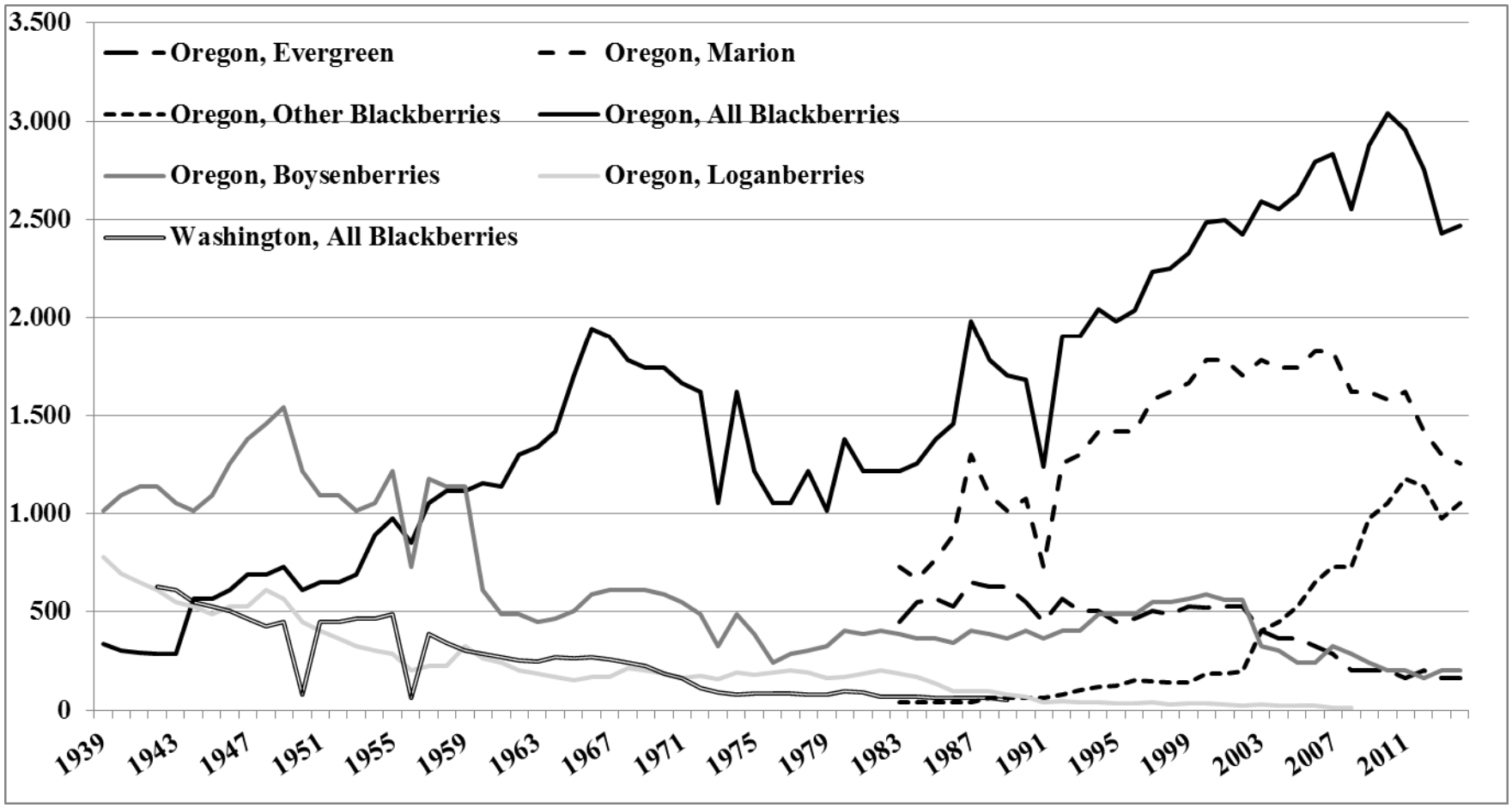

Figure 2. Historical blackberry production area (ha) in Oregon and Washington, USA; for Oregon figures, All Blackberries=Other Blackberries + Marion + Evergreen. Source: USDA-ERS, National Statistics Service.

THE 21ST CENTURY

The blackberry industry in the Pacific Northwest underwent a dramatic, and at times difficult, shift in cultivars between 2004 and 2014. While the industry had asked the blackberry breeding program in 1993 for "a thornless, machine harvestable blackberry, with better cold hardiness than 'Marion'", the actual arrival of new cultivars with these characteristics divided the industry (Finn et al., 2005a, b, c; Hall et al., 2002). The industry had expended a tremendous amount of time and money to promote "marionberry" as a high value and premium product, and some were reluctant to accept these new cultivars that might compete with 'Marion's market share. However, some growers went ahead and planted trial plantings of the new cultivars and quickly decided 'Black Diamond' was the most commercially viable of the group. Over the course of the next few years, growers found that 'Black Diamond' was much higher yielding and more cold hardy than 'Marion', could be machine harvested easily, and had good fruit quality. While some would argue that the fruit quality is as good as 'Marion', most are of the opinion that while 'Black Diamond' is large, firm, and tastes good, it does not have the wonderful aromatic flavor of 'Marion'. The positive grower trials led to a rapid expansion of area planted in 'Black Diamond' and while more plants of it than 'Marion' have been sold annually for the past 10 years, 'Marion' is still the cultivar with the most area today.

In the past two years, 'Columbia Star' and 'Willamette Thornless Marion' have been released and are expected to further decrease the area planted to thorny 'Marion' (Finn et al., 2014; Heidt, 2014). 'Columbia Star' in small trials had outstanding fruit quality, equal to or better than 'Marion', in addition to being high yielding, machine harvestable and of course thornless. Whether it will prove as widely adapted to varying conditions and locations as 'Black Diamond' will be determined within a few years. 'Willamette Thornless Marion' was found in a 'Marion' field by L. Heidt. It appears to be a stable mutation and identical to 'Marion', for better or worse. While 'Willamette Thornless Marion' has the fruit quality of 'Marion' it is also expected to have the same challenges as 'Marion', including soft fruit, being subject to color reversion (reverting from black to purple after harvest), moderate yields, and less cold hardiness than 'Black Diamond'. Regardless of whether 'Willamette Thornless Marion' and 'Columbia Star' are widely adopted it is hard to imagine that anyone will plant thorny, 'Marion' in the future.

Fresh market production has often been overlooked in discussions of production in the Pacific northwest since it is only 5-10% of the total industry; however, that small percentage is still over 100 ha making it important nationally. Consumers have always harvested the abundant wild 'Himalaya' for fresh fruit but beginning in the late 1960s growers began to plant cultivars specifically for the local and wholesale fresh market. Growers have used a mix of trailing, erect and semi-erect cultivars over the years to meet their needs. Cultivar choice has been driven by how far the fruit was going to be shipped (and thus how firm the fruit needed to be) and the season of ripening. Historically, for anything being shipped some distance, the erect blackberries, particularly 'Cherokee' and 'Navaho', and the semi-erect, particularly 'Chester Thornless', predominated. However, 'Kotata', a firm trailing cultivar, has often been shipped fresh. With the advent of the newer trailing cultivars, particularly the very early ripening ones like 'Obsidian' and 'Metolius' that have good firmness, new marketing opportunities have developed. The reluctance of many buyers to buy 'Chester Thornless' for some markets has led many growers to try to work with the much better flavored but softer 'Triple Crown'. The most commonly grown cultivars currently grown for fresh market are 'Obsidian' and 'Metolius' for the early season, 'Ouachita' for mid-late season, and 'Chester Thornless' or 'Triple Crown' for the late season. Tunnels are often used in the autumn to keep the fruit dry and extend the fruiting season and fruit shelf life. The primocane-fruiting blackberry cultivars are not a great option for open-field production in Oregon as they begin to ripen in early September and therefore do not have enough of a growing season before the first frost in autumn to produce a high enough yield to be economical. However, growers working with tunnels and using pruning techniques to increase yield can be successful with primocane–fruiting cultivars such as 'Prime-Ark®45'

and 'Prime-Ark®Freedom' (Strik and Buller, 2012; Thompson et al., 2009). Newer, earlier ripening, primocane-fruiting cultivars would be an advantage in this region. As Mexico, the world's largest producer of blackberries, extends their season beyond the "traditional" October-June, it will be more difficult for producers in the northwest to be competitive in the wholesale fresh market.

INDUSTRY CHALLENGES

As with any crop, the blackberry industry has faced a host of ever changing problems. Some problems arise quickly such as spotted winged drosophila (*Drosophila suzukii*) and others are longer term problems that require more effort and research to address. Three of the more significant problems have been the lack of available labor, the changing food safety standards making thorn contamination completely unacceptable, and the need to take year-to-year fluctuations in crop availability due to winter cold damage out of the marketing equation.

Lack of labor

The Pacific northwest has never had an overabundance of labor as it is a region that just does not have a very large population. Over several decades in the 1900s, the industry increasingly shifted from local labor to professional laborers who were often from Mexico.

Since hand picking is so labor intensive, there has been a concerted effort to develop machines that could harvest the berries. First the Iron Wino Co. (Boring, OR), then Littau Harvester (Stayton, OR), and Korvan (now Oxbo Int. Corp. Lynden, WA) developed machines beginning in the 1960s that could efficiently harvest high quality fruit. 'Thornless Evergreen' and 'Marion' were well suited to machine harvest. In the decades since development, the machines have improved tremendously as have the cultivars that are now evaluated for their adaptability for machine harvest. It is often surprising to learn that the berries harvested by machine are a more uniform, higher quality product than handpicked fruit.

While improvements in the machines will continue, as will the release of improved cultivars, the bar has been set higher with the expectation that wholesale, fresh market blackberries can be machine harvested. One grower in Oregon is already doing this and has sufficient fruit quality to ship machine harvested 'Black Diamond' fruit as far east as Salt Lake City. The East Coast is a lot further away but it is only a matter of time before machine harvested fresh market fruit could be a reality for shipping that far.

While tremendous numbers of innovations that are labor saving have occurred in the packing plants the next big time consuming cultural task is pruning and training. Prototypes of machines that will selectively prune winegrapes have been developed but they have not yet been used on blackberry.

Thorns in product…. Thornlessness and practices to reduce thorns

Over time, as liability concerns and cost of potential compensation have increased, it has become more critical to ensure that thorns are not present in product that is ready to be marketed. Cultivar development and creative horticultural tools were used to address the problem.

The breeding program had been working for decades on the development of thornless cultivars and, as described previously, a number of approaches were used to develop the thornless 'Black Diamond' and later 'Columbia Star' that have had such an impact. Surveys conducted in the late 1990s documented that most of the thorn contaminants found in machine-harvested 'Marion' fruit were the non-senescent petioles (from last year's primocanes). The attachment of these petioles became weaker as the machine-harvesting season went on, increasing the likelihood of them falling into the harvested product. Trials were initiated to try to minimize the risk of thorn contamination. Defoliants were found to be ineffective, because the 'Marion' leaf often senesces at the leaf blade-petiole juncture rather than the petiole-cane juncture (Strik and Buller, 2002). However, mechanical methods to remove these petioles were effective. Equipping over-the-row machine harvesters with brushes instead of the rotary heads and fingers used to harvest the fruit (think street

sweeper with upright brushes) reduced the potential for thorn contamination by 66% (Strik and Buller, 2002). Most 'Marion' growers now use custom contractors to "brush" their fields in late winter to reduce thorn contamination during the following harvest season (B.C. Strik, pers. observation).

Lack of winter hardiness

Losing a significant portion of the Pacific northwest blackberry crop to winter cold injury has an effect well beyond the farm where the crop was lost. For a processor to develop a new blackberry product, they need to know that the fruit will be available every year at roughly the same price and quality. Crop loss from winter cold damage can cause a significant increase in the price of the remaining crop or even worse make it totally unavailable. This frightens processors and makes them more likely to drop a cultivar with an unreliable or inconsistent supply or not develop new products. In the early 1990s, severe winter injury led to substantial crop losses and unstable prices, making this a very difficult time to get processors interested in developing new products. To address these concerns, a series of research projects were initiated to better understand cold tolerance in 'Marion' and how cultural practices affect winter injury. The LT_{50} of 'Marion' buds ranges from -5 to -23°C, depending on the primocane growing conditions and management (Bell et al., 1995; Cortell and Strik, 1997). Bell et al. (1992) observed cold damage in 'Marion' fields after air temperatures dropped to -18°C in December 1991. In addition to observed low hardiness when dormant, 'Marion' is quite sensitive to cold temperatures during the acclimation and deacclimation phase, particularly because it has a chilling requirement estimated at less than 300 h (Strik et al., 1996). Cultural practices that increase growth later in autumn such as training time (Bell et al., 1992, 1995; Dixon et al., 2015), reduce training damage (Bell et al., 1995), and weed management and irrigation practices (Dixon et al., 2015) can increase cold injury. Growers often train primocanes in February rather than August because the later trained canes are warmer on the ground during winter and suffer less cold damage (Bell et al., 1992). In addition, some growers use alternate year production systems (Strik and Finn, 2012) in 'Marion' because primocanes are more cold hardy when grown without the presence of floricanes (Bell et al., 1992, 1995).

Serendipity is a breeder's friend. It was wonderful serendipity that in a year following a particularly cold winter the population that contained 'Black Diamond' was being evaluated in the field. In addition to being adapted to machine harvest, high yielding and thornless, 'Black Diamond' came through the winter well and has exhibited good cold hardiness, better than the standard 'Marion', since that time (Dixon et al., 2015). A series of years with milder winters combined with extensive plantings of 'Black Diamond' have allowed the industry to have stable production at a good but relatively stable price leading to more product development and greater demand.

PRESENT CHALLENGES THAT NEED TO BE ADDRESSED TO ENHANCE FUTURE PRODUCTION

The blackberry industry in the Pacific northwest is thriving. The industry is not increasing in area as dramatically as seen for blueberry but there has been a very steady rise in production and a rise in what growers can earn per hectare on blackberry through better cultivars, better management practices, and higher demand.

Labor continues to be the major problem. It is expensive and, more critically, hard to find enough people to do often back breaking labor. Anything we can do with new cultivars, management practices or increased mechanization will help the growers and more efficiently utilize the limited pool of farm laborers.

In the breeding program, we are looking at developing what sounds like an oxymoron, erect trailing blackberry cultivars. These cultivars have the fruit quality characteristics of the western trailing blackberry but are more erect thereby reducing training labor costs. We are looking at genotypes with short or shorter internodes that might fit into a very different high density planting system. We are always pushing for more yield of high quality fruit as we do not think we have approached the point where you have maximum yield without sacrificing

quality.

While we continue to tweak production systems, particularly optimizing fertilizer programs and assessing plant nutrient status (Strik and Bryla, 2015) the most recent cultural advances include development of economical organic production systems for machine-harvested processed markets (Dixon et al., 2015; Fernandez-Salvador et al., 2015a, c; Harkins et al., 2013) and fresh markets (Fernandez-Salvador et al., 2015b). Growers will need to continue to explore high value niche markets to be successful.

CONCLUSIONS

Blackberries have had an amazing breeding and horticultural history in the Pacific northwest and the future only looks brighter. The Mexican blackberry boon has brought many new customers to the crop. Area and production for fresh market have been expanding rapidly with new public and private cultivars and the new primocane-fruiting cultivars initially developed at the University of Arkansas. We are a biased bunch in the Pacific northwest, but feel that if we can encourage consumers to purchase fresh blackberries, they will be motivated to use our frozen berries in recipes or in products that we can drive satisfaction and demand even higher.

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