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Sweet Cherry Cultivars Vary in Their Susceptibility to Spring Frosts

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***Abstract*. Spring frosts can be a limiting factor for sweet cherry production and very little is known about frost susceptibility of new sweet cherry cultivars. This study reports on floral bud injury of a number of recently introduced sweet cherry cultivars after 10 spring frosts in Apr. 2008. Floral buds at the first white stage were collected from late-ripening sweet cherry cultivars that were part of a randomized and replicated evaluation block. Blossoms were selected from various positions within a tree in a 1-m band centered around 1.5 m above the ground. The blossoms were brought into the laboratory, cut open, and placed into two groups: live (green) or dead (brown or browning) pistil. 'Staccato' and 'Sentennial' were the least affected followed by 'Lapins' and 'Sweetheart'. 'Sovereign' was most susceptible to the subfreezing temperatures in the spring of 2008. There was a reasonably good relationship between the percentage of live buds per tree in the spring and yield at harvest later in the summer.**

Low-temperature injury to sweet cherry fruit buds during bloom can significantly reduce production. Careful site selection to avoid spring frosts is an important consideration when planting new sweet cherry orchards (Longstroth and Perry, 1996). Watson (2005) recommends sites with good air drainage, good air movement, light soils, and proximity to a heat sink. Other frost protection techniques include heaters, wind machines or helicopters, overcrop sprinkling, under-tree sprinkling, and covers (with or without heating) (Watson, 2005). All these techniques require either water or energy to generate air movement with associated costs. It is therefore important to have an understanding of the susceptibility of sweet cherry cultivars to spring frost. Proebsting and Mills (1978) established the critical temperatures for the various stages of flower development in the spring for 'Bing' sweet cherry. Knowledge of the frost sensitivity of sweet cherry cultivars can aid in orchard design by placing most susceptible cultivars in the best sites and also, frost protection should be started sooner on the more susceptible cultivars. The objectives of this study were to quantify floral bud injury after a spring frost in the 2008 season.

Spring frosts occurred the nights of 19, 21, and 22 Apr. 2008 in the Okanagan Valley of British Columbia, Canada. The morning of 23 Apr. 2008 a range of recently introduced sweet cherry cultivars grown at the Pacific Agri-Food Research Center, Summerland, British Columbia, were evaluated for injury to fruit buds. Most cultivars were at the first white or Stage 6 of the Washington State University chart (Ballard et al., 1997). The cultivar Sovereign was slightly behind in development.

The trees sampled were the late-maturing cultivars Lapins, Sweetheart, Staccato, Sovereign, and Sentennial, which were in a randomized, replicated evaluation trial planted in 1998. There were six single tree replicates arranged in a randomized complete block design and $\approx$100 blossoms per tree (replicate) were collected. The trees were on Mazzard rootstock, trained to a modified central leader system, and received irrigation and pesticides according to local recommendations.

Blossoms were selected from various positions within a tree in a 1-m band centered around 1.5 m above the ground. The blossoms were brought into the laboratory, immediately cut open, and placed into two groups, that is, live (green) or dead (brown or browning) pistil.

Fruit were harvested from the late-maturing cultivars when they had reached commercial maturity. The yield per tree (kilograms per tree) was then related to the percentage of live buds per tree.

The data from the group of trees were analyzed using the General Linear Model procedure (SAS Institute, Inc., 1989) and least-square means were generated because of missing data for one of the cultivars and they were compared using the PDIFF option.

There were a total of 10 nights when temperatures were below 0 °C during the month of Apr. 2008 at the Pacific Agri-Food Research Center, Summerland, British Columbia, Canada (Fig. 1). Flowers were beginning to open when the frost during the nights of 19, 20, 21, and 22 Apr. had minimum temperatures of –4.0, –2.4, –4.3, and –2.7 °C, respectively. Ballard et al. (1997) determined that the average temperature when 10% of sweet cherry buds were killed ranged from –2.2 to –8.3 °C depending on stage of bud development. Over the last 78 years (1931 to 2008), the last killing frost (–2.2 °C) in Summerland, British Columbia, can occur into the first of May (Fig. 2). The dates of 10% bloom for 'Lapins', 'Sweetheart', 'Staccato', 'Sovereign', and 'Sentennial' ranged from 23 to 25 Apr. putting them at risk for freeze injury in some years. As buds deacclimate and approach anthesis, they lose the ability to deep supercool.

The sweet cherry cultivar Sovereign had the greatest injury with almost 80% of its blossoms killed by the frost (Table 1). 'Staccato' and 'Sentennial' were the hardiest with only approximately one-third of the blossoms dead. 'Sweetheart' and 'Lapins' were intermediate with over half of their blossoms dead. The development of the blossoms of 'Sovereign' lagged behind the other cultivars in this orchard. The expectation is that blossoms that are not as advanced should be less susceptible to freezing injury than more advanced blossoms (Rodrigo, 2000).

It is unclear what mechanism causes different levels of injury to the different cultivars. Unlike previous findings (Rodrigo, 2000), later-developing flower buds were not always less susceptible to freezing than more advanced buds as demonstrated by the later-blooming cultivar Sovereign, which suffered greater injury than early bloomers. The presence and activity of ice nucleation–active bacteria (Lindow, 1983) or intrinsic ice nucleators (Ashworth, 1992), which promote supercooling protection against freezing, may differ among different cultivars. Similarly, moisture content (Rodrigo, 2000), which is considered to increase freezing risk and reduce supercooling (Andrews and Proebsting, 1987), may vary among the cultivars evaluated in this report. Flinn and Ashworth (1995) reported that winter flower bud hardiness of *Forsythia* may be related to carbohydrate levels. Lasheen and Chaplin (1971) reported some correlation between the levels of biochemical constituents (sugars, proteins, and amino acids) and the degree of hardiness of flower buds in three peach cultivars. Which of these factors influence the different responses of the cultivars is unknown.

There was a reasonably good relationship between the percentage of live buds per tree and yield at harvest (Fig. 3). Whether these yield reductions would have economic impacts depends largely on the severity of the reduction and the price differential for the various size categories. Growers receive premiums for the larger sized fruit and with a reduced crop, generally there would be an expectation for larger fruit.

Knowledge of the sensitivity to spring frosts by these sweet cherry cultivars would aid growers in placement of the various cultivars in orchards. If the cultivar Sovereign is grown, it should be planted in the most favorable site in relation to spring frost avoidance. Also, if frost protection is practiced, then it should be initiated at a higher temperature for 'Sovereign' than for 'Staccato' or 'Sentennial'.

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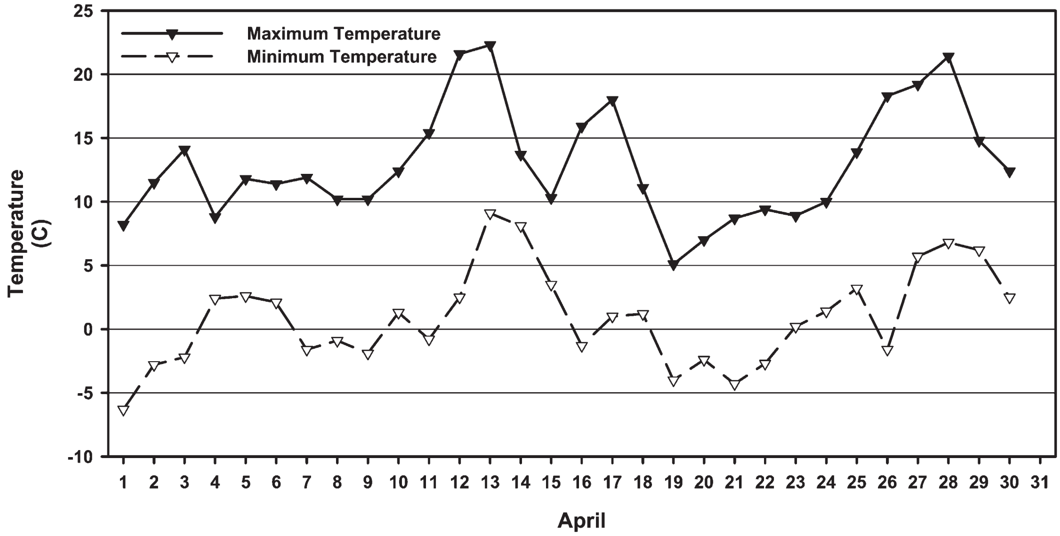

Fig. 1. Daily maximum and minimum temperatures in Apr. 2008 at Summerland, British Columbia.

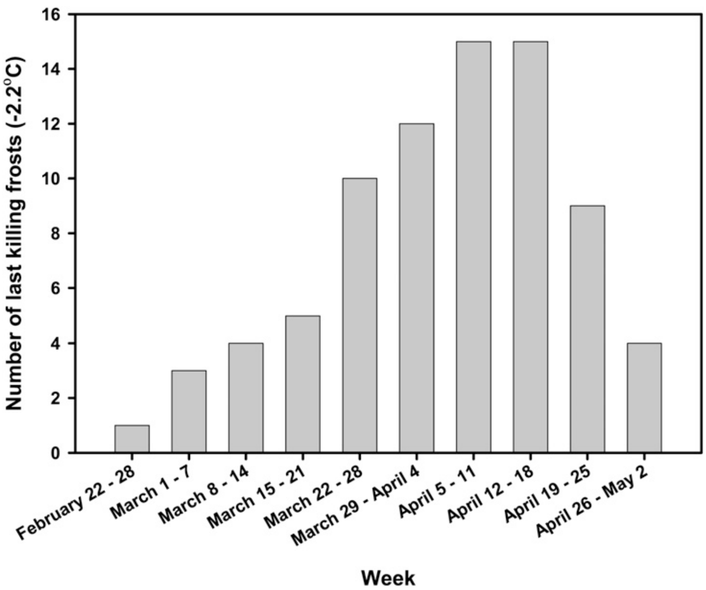

Fig. 2. Frequency of the last killing frost (–2.2 °C or less) over the past 78 years (1931 to 2008) at Summerland, British Columbia.

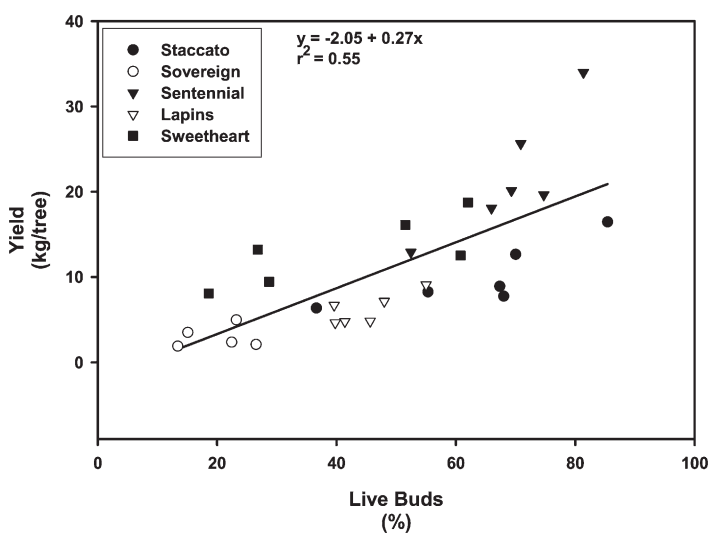

Fig. 3. Relationship between the per cent live buds of sweet cherries after a spring frost and yield.

Table 1. Sweet cherry blossom mortality of late-ripening cultivars after a spring frost, Apr. 2008.

Cultivar	Dead blossoms (%)
Sovereign (13S-21-01)	78.6 a[z]
Sweetheart	58.6 b
Lapins	55.1 b
Staccato	36.2 c
Sentennial (SPC103)	30.9 c

[z]Least squares means with different letters are significantly different at $P \leq 0.05$ (SAS pdiff option).

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