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# Effects of Spring Frosts on Four Apple Cultivars

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## Abstract

The effects of two successive frosts on pistil mortality and on young apples were studied on the cultivars 'Lobo,' 'Melba,' 'Cortland' and 'McIntosh' in two apple orchards located at high and low elevation sites at Frelighsburg, Que. The first frost occurred at bloom stage on May 2, 3 and 4th and the second frost was experienced on June 3rd, 1986. The low elevation orchard was colder and its trees were more seriously affected by the frosts than the trees of the high elevation orchard. 'Cortland' flowers exhibited a certain degree of cold tolerance but the young apples were very sensitive to low temperatures. The last frost killed drastically more young fruit of 'Melba' in the low elevation orchard. After 'Melba,' 'Lobo' had the highest number of fruit survival after the second frost. It is suggested that its higher fruit set may be attributable to its extreme cold hardiness. In both orchards, the reduction in the number of viable fruit of 'McIntosh' and 'Cortland' was pronounced after the second frost. During bloom and early fruit formation, no difference in cold resistance could be observed among the cultivars.


## Introduction

Quebec apple growers historically paid a high toll to cold injury, especially to winter injury. Perusal of the relevant literature reveals that there was severe winter injury in 1856-57 (9), 1874-75 (9), 1895-96 (5), 1903-04 (3), 1917-18 (7), 1933-34 (15, 2), 1956-57 (17), 1963-64 (6) and 1980-81 (12).

The 1933-34 winter-injury accelerated a shift from the 'Fameuse' to 'McIntosh.' In 1980, Quebec produced 11.51 tons of apples, i.e. 21.1% of the Canadian apple production. Following the 1980-81 winter injury, the production was down to 10.7% of the Canadian production (4). These significant tree losses caused the replantation of several apple cultivars on dwarfing rootstocks, such as M.26, M.9, Ott.3, or semi-dwarfing stempieces such as M.9 on MM.106, and M.9 on MM.111, or semi-dwarfing rootstocks such as M7.

Although cold hardiness ranks high in apple breeders' priorities in North Eastern America, little work was done on spring frost resistance. Observations on spring injury to the blossoms and the fruit are few in the pomological literature. Thomas (14) described the injury caused by late frost to fruit of *ca.* 2-2.5 cm in diameter. Frost on the fruit may cause the apple to drop or to exhibit malformations. The appearance of the injuries was different in the four cultivars observed. The fruit of 'Sturmer Pippin' appeared lobsided, and constricted growth created a furrowed effect. On 'Cleopatra,' the skin surface was scored and pitted with a deep crinkle, while on 'Scarlet,' only slight malformations were observed.

In spring 1986, several apple growing regions of Southwestern Quebec experienced late frost on the blossoms and a few days after the calyx stage, on young apples. The effects of these late frosts on four apple cultivars are reported here. To our knowledge, this is the first report on the effect of consecutive frosts on the blossoms and the fruit. The effect of microclimate on late frost injury is also treated.

## Material and Methods

The study was carried out in two orchards located on the Experimental Farm of Agriculture Canada at Frelighsburg, Quebec (45°03'N,72°50'W) in 1986. The 2 orchards were located on the upper and lower part of a hill, respectively at 94 and 115 m above sea level, with a distance of 215 m between the orchards. In both or-

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chards, the measurements were made on four trees of 'McIntosh,' 'Cortland,' 'Lobo,' 'Melba,' of 50 years standard trees grafted on seedlings. The dates of the phenological stages for 'McIntosh' (our reference cultivar) were as follows: Green tip, April 17; Half-inch green, April 18; Tight cluster, April 28; Pink, May 1; Bloom, May 15; Petal fall, May 18; Fruit set, May 22. On May 11-14th, 100 clusters were chosen at random. The number of flowers per 100 clusters and number of pistils affected by frost was the presence of tissue necrosis. Each cluster, chosen at random in a comparable sunny location of the tree, was tagged allowing subsequent observations to be made on the same clusters. On May 25-30, the number of young fruits was counted. On June 18th (i.e. before June drop), the number of sound fruits in each cluster was also counted.

The temperature was recorded with one hygrothermograph per orchard placed in standard Stevenson screens. The first frost occurred during the nights of May 2, 3, and 4 (Fig. 1) while 'McIntosh' was between the pink and bloom stages. The second frost occurred after fruit set on June 3rd. Within each orchard, the data were subjected to the analysis of variance and Duncan's Multiple Range test to assess differences among cultivars.

**Results and Discussion**

The number of flowers counted on the 100 clusters was statistically uneven ($p = 0.05$) (Table 1). Experimental variation between the four trees of the cultivars was low for all parameters as indicated by a coefficient of variation less than 30 following analysis of variance.

The lower elevation orchard experienced lower temperatures during the critical periods (Figure 1). For all cultivars except 'Cortland,' the seond frost damage was more severe in the lower orchard (Table 1). Following the first frost, 'Cortland' was significantly less affected than other cultivars in the lower elevation orchard. However, it proved to be more sensitive to the later spring frost. At both elevations, but more so in the low elevation orchard, only a low percentage of 'Lobo' young apples could be counted after the first frost. This indicates that 'Lobo,' reported by Asnong (1) as the most cold hardy cultivar presently grown in Quebec, is nonetheless very sensitive to frost at bloom stage.

After the second frost, 'Lobo' fruit proved less sensitive to cold than other cultivars as revealed in both orchards by its significantly higher percentage of remaining fruit. 'Melba' had a high percentage of remaining fruits after the second frost in the higher eleva-

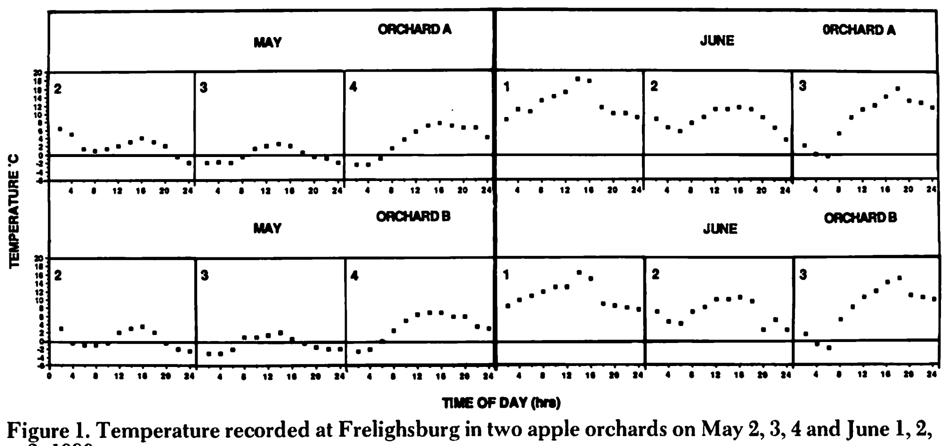


**Figure 1. Temperature recorded at Frelighsburg in two apple orchards on May 2, 3, 4 and June 1, 2, 3, 1986.**

**Table 1. Effect of two spring frosts on four apple cultivars at Frelighsburg, Qué. 1986.**

| | Mean number of flowers examined per 100 clusters | % of flower survival after the first frost | % of fruit survival after the first frost | % of fruit survival after the second frost |
|---|---|---|---|---|
| **High elevation orchard** | | | | |
| 'Lobo' | 432.2a[1] | 47.0a | 30.1bc | 23.6c |
| 'Melba' | 352.2ab | 41.2ab | 43.1a | 41.5a |
| 'Cortland' | 369.5ab | 42.8ab | 42.0ab | 1.9c |
| 'McIntosh' | 341.5b | 32.6b | 22.6c | 1.8c |
| **Low elevation orchard** | | | | |
| 'Lobo' | 414.7a | 23.7b | 20.2c | 12.5a |
| 'Melba' | 386.0a | 37.0b | 51.0a | 1.8b |
| 'Cortland' | 263.5b | 50.6a | 50.0a | 3.7b |
| 'McIntosh' | 408.5a | 31.1b | 32.1b | 0.3b |

[1]Vertically, means followed by the same letter are not statistically different at P = 0.05, Duncan's Multiple range test.

tion orchard, but its fruits were almost completely frosted out in orchard at the lower elevation. Being an early cultivar, 'Melba' fruits grew very rapidly in spring time. Therefore during the second frost on June 3rd these fruits were more developed than those of other cultivars and were more prone to frost injury. The slight difference in temperature between orchard elevations was enough to kill out most of the 'Melba' apples. The possible effect of wind was not investigated. Several remaining fruit damaged by the frost were lopsided (Figure 2). These malformations persisted until harvest. A transverse cut through the fruit displayed brownish tissues as shown by Thomas (14).

Further work on hardiness should be done before a physiological mechanism could be pinpointed as responsible for hardiness of young apple fruit. Modlibowska (8) stated that low water content and high sugar and starch content of flowers are important parameters to explain the susceptibility of apple blossoms to cold injury. Although evidence of variations in water and sugar contents in the young fruit were presented by Smock and Neubert (13), physiological mechanisms explaining the differential effect of the frost on small apples are yet poorly understood. This type of information would be useful to plant breeders to incorporate hardiness in new apple cultivars.

Our data also suggest that hardening of the blossoms and hardening of young fruit are not correlated in certain cultivars. If this is true, the 3

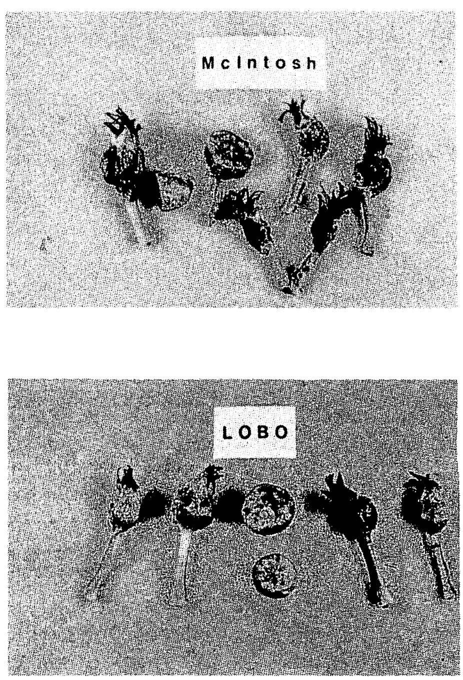


**Figure 2. Blemished fruit resulting from two spring frosts, on 'McIntosh' and 'Lobo.'**

hardiness periods postulated by Proebsting (10, 11) would therefore end after fruit set and there should be a period beyond which there are no hardening. From a practical standpoint, critical temperature thresholds can be reached in some part of the orchards due to either cultivar, topography or microclimate, and the effects of a light frost could be patchy. The success of frost protection measures, as described in Westwood (16), would therefore depend on the temperature and the cultivar. On small fruit, 1.5°C colder temperature, made a dramatic difference in potential harvest, especially on late cultivars. Whether the growers should protect summer or late cultivars during frost warning remains a management decision. A conservative grower would protect early or mid-season cultivars (e.g. 'Melba' and 'Lobo') while the protection of late cultivar (e.g. 'McIntosh' and 'Cortland') would be desirable (but risky) if the temperature is not lower than -0.5°C.

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