2023-05-31

WINTER 2023 APPLE POST FREEZE REPORT

Prepared by Ian Willick (ian.willick@agr.gc.ca), Precision Horticulture Program, KRDC, Agriculture and Agri-Food Canada (AAFC), Kentville, NS, B4N1J5.

Summary

***Freezing events**:* On February 3 and 4, night temperatures dropped to -25°C and -27°C. This was the coldest widespread temperatures observed in Nova Scotia since 2009. A second freezing event occurred on February 27th where nighttime temperatures ranged from -17°C to -25°C.

Warm winter temperatures left trees more susceptible to injury: The average December and January temperatures were the warmest recorded since 1914. Despite this issue, buds from the three tested varieties were undamaged following the freezing events. Visual observations in less hardy cultivars such as Gravenstein suggest that more susceptible varieties may experience injury to the king bud or complete bud loss due to vascular collapse in the Spring.

Potential issues heading into the growing season: Apple trees will likely be weaker going into the growing season. Check on blocks with known nutritional deficiencies such as dull leaves in the spring. We may see site- and block-specific vascular collapse in tender varieties. Weak trees will also be more susceptible to insect and disease pressure.

Detailed Description

The freezing tolerance of tree fruits is dependent on the following factors: the maximum level of cold hardiness attained by a given tree, the rate of cold hardiness acquisition in the fall, the stability of cold hardiness over winter, and how quickly a tree de-hardens when exposed to warm temperatures. Hence, the successful overwintering performance of any tree fruit requires the synchronization of the annual development of cold hardiness with seasonal temperature changes. Acquisition of cold hardiness in tree fruits grown in Nova Scotia occurs through a three-stage process known as cold acclimation (Weiser 1970). First, exposure to shortening day lengths in September begin to slow the rate of vegetative growth. Mature apple trees begin to set their terminal buds during this period. Cool night time temperatures in October and November during the second stage of cold acclimation will promote the onset of bud dormancy. It is during this period that trees will accumulate cryo-protectant sugars and proteins to enhance their cold hardiness. Leaf fall occurs during this transition. Tree fruits exposed to frost and prolonged sub-zero temperatures in November and December undergo a third stage of cold acclimation which results in the further accumulation of cryoprotectant sugars and the acquisition of maximum levels of cold hardiness.

The sequence of tree fruits first experiencing shortening day lengths and then low temperatures is essential to attaining maximum levels of cold hardiness. Temperatures prior to a freezing event are important because cool temperatures between -1°C and -10°C are needed for cold hardy tree fruits to enhance their cold hardiness. Temperatures on average of 0.5°C in December 2022 and January 2023 disrupted the stability of tree fruit cold hardiness over winter (Figure 1). This left the tree fruit buds more susceptible to a late winter freeze.

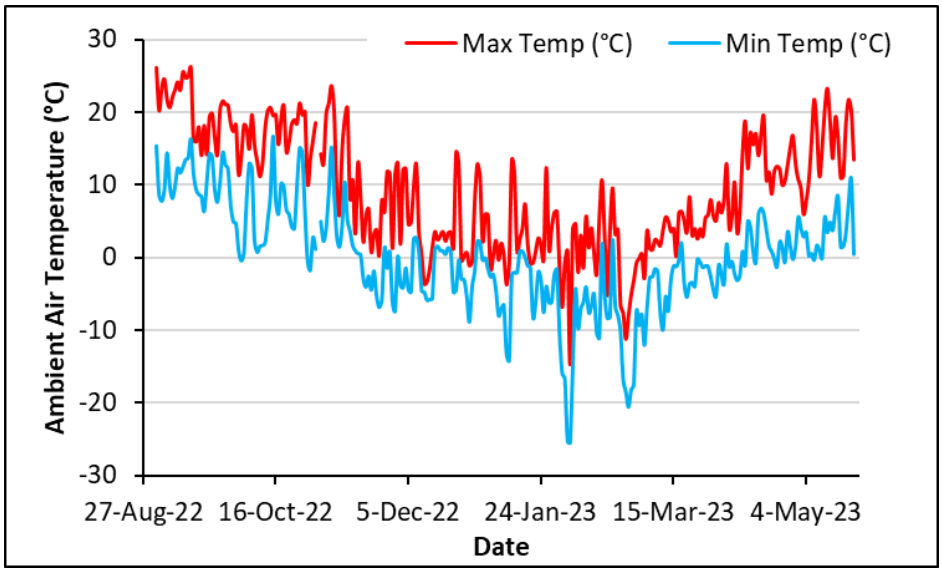

Figure 1. Ambient air temperatures near the Kentville Research Station**.**

Nova Scotia experienced an advective freeze event on February 3rd to 4th (Table 1). Relatively uniform air temperatures during this freeze event across Nova Scotia resulted in widespread injury in most woody perennial crops. See the Orchard Outlook Newsletter Vol. 23, No 1 on the NS Tree Fruit Blog for more information. Managing these low temperatures with burning bails (impractical) and wind fans (lack of infrastructure) was not possible due to the uniform air temperatures and high winds during this freezing event. The temperature inversion freezing event on February 25th and 26th resulted in cold air pools resulting in larger discrepancies in temperature and the potential for injury within an orchard.

Table 1. Minimum air temperatures by site during two freezing events.

Site*	Latitude (°N)	Feb 3-4 (°C)	Feb 25-26 (°C)
Caribou[1]	45.73	-26.5	-16.6
Kentville[1]	45.07	-25.5	-20.6
Greenwood[1]	44.97	-25.2	-24.2
Morristown[2]	44.98	-26.0	-21.0
Melvern Square[2]	44.98	-25.0	-19.0
Yarmouth[1]	43.83	-21.8	-12.2
Waterville-Cambridge[1]	45.04	-26.0	-23.0
Aylesford[2]	45.02	-26.0	-25.0
Atlanta[2]	45.15	-25.0	-17.0
Grafton[2]	45.10	-26.0	-25.0
Aldersville[1]	44.82	-26.7	-20.1
Moschelle[2]	44.75	-25.0	-19.0

*Temperature data from each site originated from either Environment Canada (1) or NSFGA (2) weather stations.

Bud hardiness was calculated from electrolyte leakage freezing assays and based on the lethal temperature at which half the buds were injured (LT50). The crop for the current season resides in these dormant buds. Gala, Ambrosia and Honeycrisp buds sampled on February 2nd 2023 developed an LT50 between -28°C and -32°C (Table 2) whereas in mid-winter fully cold acclimated Gala, Ambrosia and Honeycrisp 50% injury to xylem tissue can occur at -37°C, -38°C and -40°C (calculated from Cline et al. 2012).

While Honeycrisp at each sampling date were more cold hardy than Gala and Ambrosia, this is not necessarily a reflection that they were less impacted by warm weather. Honeycrisp is generally more cold hardy than Gala and Ambrosia in a 'normal' winter (Cline et al. 2012). There are unfortunately no available records detailing Ambrosia, Gala and Honeycrisp bud cold hardiness levels in Nova Scotia that could be used as a historical comparison. Regardless, the tested cultivars developed an LT50 that was lower than the recorded low minimum temperatures on February 3rd to 4th and February 25th to 26th (Figure 1). Subsequent field sampling suggests buds within these blocks did not experience an injurious freeze, whereas more tender varieties such as Gravenstein experienced a degree of bud injury (Figure 2). We will begin to see more mid-winter injury in tree fruits if recent weather trends continue.

Table 2. Lethal temperature at which half the buds were injured (LT50).

Sampling dates	LT50 (°C) Ambrosia	Gala	Honeycrisp
Dec 6, 2022	-26.9	-28.6	-29.0
Feb 2, 2023	-27.8	-29.7	-32.4
Mar 9, 2023	-25.4	-26.8	-28.6

Nova Scotian apple trees are also vulnerable to injurious frosts in the late spring following bud break. There is considerable variability in susceptibility to freezing injury among tree fruits, cultivars and developmental stages. Buds become more susceptible to freezing injury as they swell and expand into blossoms (Table 3). Whereas slowly developing buds tend to retain their cold hardiness for longer and are less susceptible to warming conditions. The table below illustrates the average temperatures required for the lethal injury of 10% and 90% of buds. This information should only be used as a guideline as weather conditions preceding a frost event will either increase or decrease bud hardiness.

Figure 2. A) Uninjured Honeycrisp bud following the freezing events. B) Lethal injury in Gravenstein primordia. C & D) Vascular injury in Gravenstein.

Acknowledgements

We graciously acknowledge the support and assistance of Michelle Cortens (Tree Fruit Specialist, Perennia) during sampling, for discussions regarding tree fruit health, and for providing photos included in Figure 2. Funding for this work was graciously provided by the Nova Scotia Fruit Growers Association through project J-003117 - Prepare to be blown away: assessment of pneumatic leaf removal on Nova Scotia apple cold hardiness and fruit colour. If you have any questions or comments, please contact the KRDC Precision Horticulture Program using the contact information listed above.

Table 3. Average critical temperatures (°C) for apple blossom buds.

	Silver Tip	Green Tip	½" Green	Tight Cluster	First Pink	Full Pink	First Bloom	Full Bloom	Post Bloom
Standard	-8.9	-8.9	-5.6	-2.8	-2.8	-2.2	-2.2	-1.7	-1.7
10% kill	-9.4	-7.8	-5.0	-5.8	-2.2	-2.2	-2.2	-2.2	-2.2
90% kill	-16.7	-12.2	-9.4	-6.1	-4.4	-3.9	-3.9	-3.9	-3.9

Notes: 'Standard' refers to the lowest temperature that can be endured for 30 minutes without injury. Values presented in this table were collected from Ballard et al. (1998).

References

Ballard JK, Proebsting EL, Tukey RB (1998) WSU EB0913 Critical temperatures for blossom buds – apples. Washington State University Extension Bulletin.

Cline JA, Neilsen D, Neilsen G, Brownlee R, Norton D, Quamme H (2012) Cold hardiness of new apple cultivars of commercial importance in Canada. Journal of the American Pomological Society 66: 174-182.

Weiser CJ (1970) Cold resistance and injury in woody plants: knowledge of hardy plant adaptations to freezing stress may help us to reduce winter damage. Science 169: 1269-1278.