Understanding Cranberry Frost and Winter Hardiness

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Study of the cranberry plant's cold hardiness levels throughout the year has long been considered to be important by growers. Better and more complete information on the ability of the cranberry plant to resist freezing stress damage will aid in making better frost and winter management decisions. The goals of our research program are to: 1) define seasonal changes in cranberry hardiness; 2) learn about the mechanisms the cranberry plant utilizes to survive freezing stress; 3) develop a predictive model linking plant development and hardiness, based on field temperatures; and 4) develop recommendations for improved frost and winter management. For the last two years we have focused on investigating leaf and bud hardiness in the spring and fall, fruit hardiness in the early fall, the possibility of significant hardiness changes under the winter ice, and the collection of field temperature data.

General methodology

Samples for all of our experiments were collected from 'Stevens' beds in the Nekoosa area. Samples were cut and moistened, and then transported on ice to our laboratory in Madison. Uprights were sorted, cut to a uniform length, and prepared in large test tubes for freezing in a circulating glycol (antifreeze) bath. Temperatures in the bath were lowered incrementally and held for 30 minutes. Samples were removed at given temperatures and then allowed to thaw slowly. Damage to parts of the uprights were evaluated visually both soon after the experiment as well as after a period of weeks during which the uprights were allowed to regrow in the laboratory or the greenhouse.

Spring leaf and bud hardiness

Q1: How hardy are terminal buds and leaves in the spring?

Q2: How does bud and leaf hardiness relate to crop phenology?

All spring samples were sorted according the stages of bud present. Those stages are: tight bud, swollen, cabbagehead, bud break, bud elongation, rough neck, hook, and bloom. Color illustrations of these stages were published in the February 1997 issue of *Cranberries* magazine. Changes in the distribution of bud stages present over time (ultimately related to climatic conditions) is referred to as the crop's phenology. In the spring of 1996 and 1997 our freezing experiments focused on defining the hardiness of buds and leaves at particular bud stages (and in 1996 throughout the growing season) (Figures 1 to 3 and Table 1). The most numerous bud stages present on a given sample date were selected for the freezing experiment.

Al: Last year leaves appear to be initially hardy to ~ 6 to 10°F, then deacclimate some time in mid-May, eventually reaching a hardiness ~ 25 to 28 °F. Current year leaves are hardy to only 32 °F when first emerging. This new growth develops a hardiness of ~ 20 °F by early summer. Terminal buds appear to be hardy to ~ -10 to -8 °F when the winter flood is first drained. By the time of bud break they can only resist temperatures to ~28 to 30 °F.

A2: The cranberry plant becomes more sensitive with changes in phenology (across bud stages). However, deacclimation can occur without changes in phenology (within a given bud stage).

What next? Our studies show that cranberry hardiness and phenology are related to the temperatures the plants experience. From the data we are collecting, our goal is to develop a model to predict both development and hardiness during the spring.

Early fall fruit hardiness

Q3: Can fruits survive temperatures much below 32 °F ?

Q4: Are there differences in fruit hardiness based on degree of ripening?

We tested fruits that were <50% blush/red and >50% blush/red (Figures 4 and 5). Damage was evaluated as the percent watersoaking seen on the cut surface of fruits. When damage was induced, less ripe fruits typically showed more severe damage. This pattern of damage suggests that cranberry fruit survive freezing stress by supercooling (the avoidance of the formation of ice in the tissues, or the maintenance of liquid water at sub-freezing temperatures). This idea is supported by observations we made using the technique of infrared video thermography (IVT). Using IVT, we are able to "watch" freezing events as the heat given off by freezing water is visually depicted on a television monitor. This work suggested that cranberry fruit do not self-nucleate (freeze from within) and that the only external source of ice propagation is through the calyx end of the fruit. We also performed duration experiments on fruit and found that ripe fruits were able to withstand 25°F for up to one hour.

A3: Full size fruit appear to be able to survive temperatures down to ~ 25 °F for up to one hour.

A4: Less ripe fruits were found to be more sensitive to sub-freezing temperatures than more ripe fruits.

What next? Further study of the development and structure of fruits will increase our understanding of how they survive freezing stress.

Fall leaf and bud hardiness

Q5: How does leaf and bud hardiness change in the fall?

In the fall of 1996 we sampled uprights weekly from three different beds and performed freezing experiments. Sampling began in mid-September and continued until mid-December just prior to the winter flood. After thawing, uprights were given additional chilling hours to break dormancy, and then were planted in the greenhouse. Figure 6 depicts the changes in hardiness throughout the fall.

A5: By the beginning of November, buds and leaves are hardy to ~ -15 °F. Some hardiness was temporarily lost as a result of the flooding and physical damage associated with harvest

What next? We are repeating this set of experiments to confirm these data.

Hardiness levels under the winter ice

Q6: Does the hardiness of the cranberry plant change under the winter ice?

In mid-March of 1997 we obtained samples from under the winter ice. In relation to hardiness levels in mid-December (just before the winter flood) and mid- April (just after removal of the winter flood), cranberry bud and leaf hardiness levels (°F) were determined as follows:

	12/18/96	3/10/97	4/15/97
leaves	±-13	~ 14	1 0
buds	±-13	~- 4	± - 8

A6: It appears as though leaves deacclimate somewhat under the ice, while the hardiness of buds do not appear to change greatly.

What next? We will be repeating this experiment to confirm these data.

Conclusion

A picture of the cyclical nature of the cold hardiness of the cranberry plant is gradually emerging from our data. We are looking forward to further study of hardiness levels, as well as to the creation of a predictive development and hardiness model, and to continued study of bud and fruit development.

Acknowledgements

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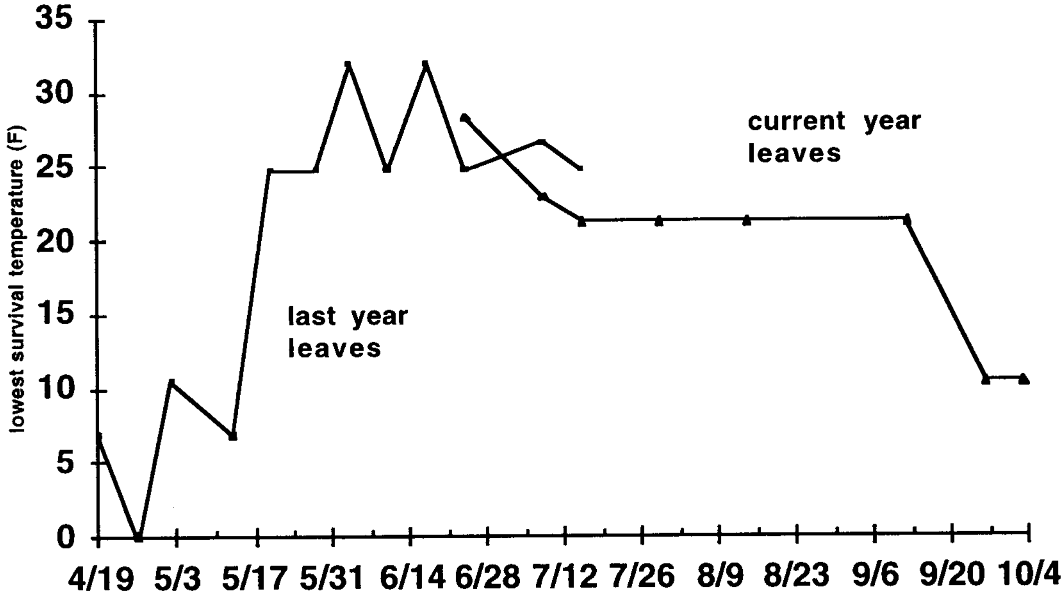

Figure 1. Lowest survival temperatures of last and current year leaves from samples collected throughout the 1996 growing season.

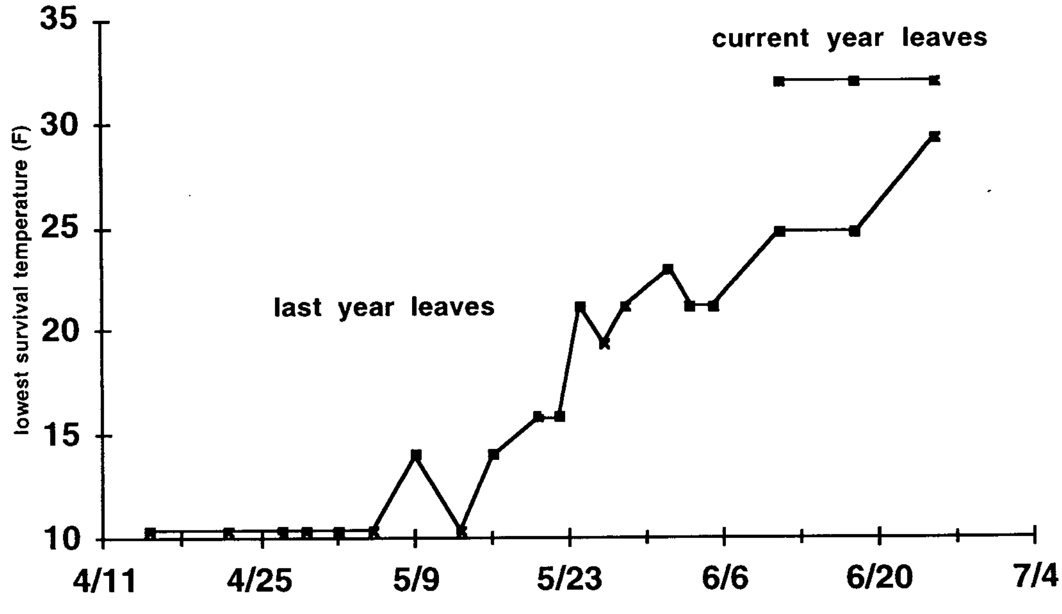

Figure 2. Lowest survival temperatures of last and current year leaves from samples collected in the spring of 1997.

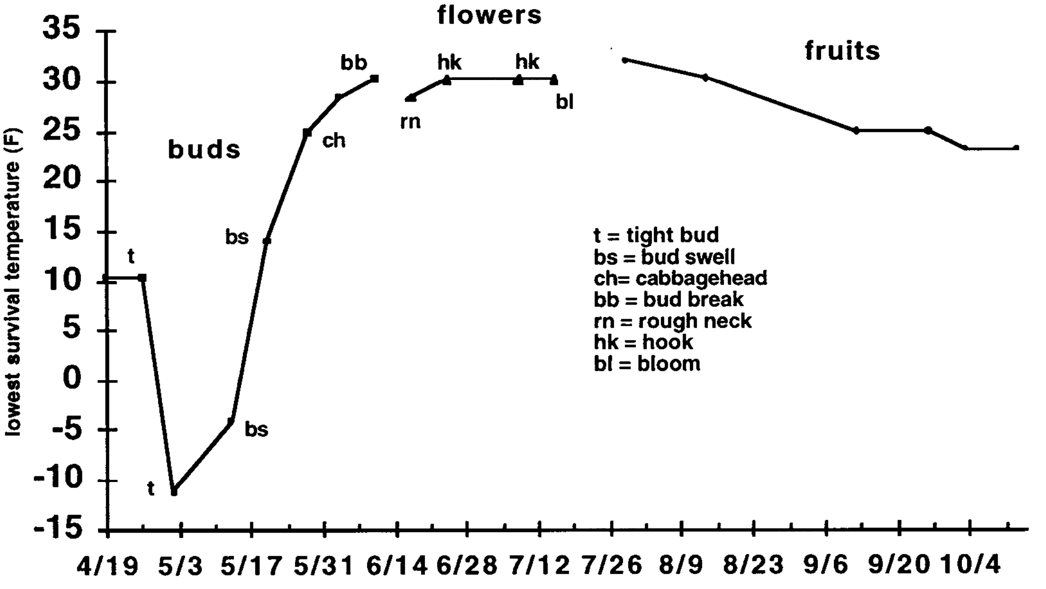

Figure 3. Lowest survival temperatures of terminal buds, flowers, and fruits from samples collected throughout the 1996 growing season.

	T	BS	CH	BB	BE	RN	EH	HK
4/15	≤ -8	≤ -8						
4/22	~ 0	~ 0						
4/27	≤ -8	≤ -8						
4/29	≤ -8	≤ -8						
5/2	3	3						
5/5	≤ -4	≤ 0						
5/9	~ 10	~ 10						
5/13	10	16						
5/16	10	14						
5/20	10	~ 23						
5/22	14	23						
5/24	21	25						
5/26	25	25						
5/28	25	25	28					
5/30		28	28	32				
6/1		> 25	28	28				
6/3			28	28	29			
6/5				30	30	32		
6/11					30	32		
6/18						30	32	32
6/25								32

Table 1. Lowest survival temperatures of terminal buds ("F) from samples collected in the spring of 1997. T=tight, BS=bud swell, CH=cabbagehead, BB=bud break, BE=bud elongation, RN==roughneck, EH=early hook, and HK=hook.

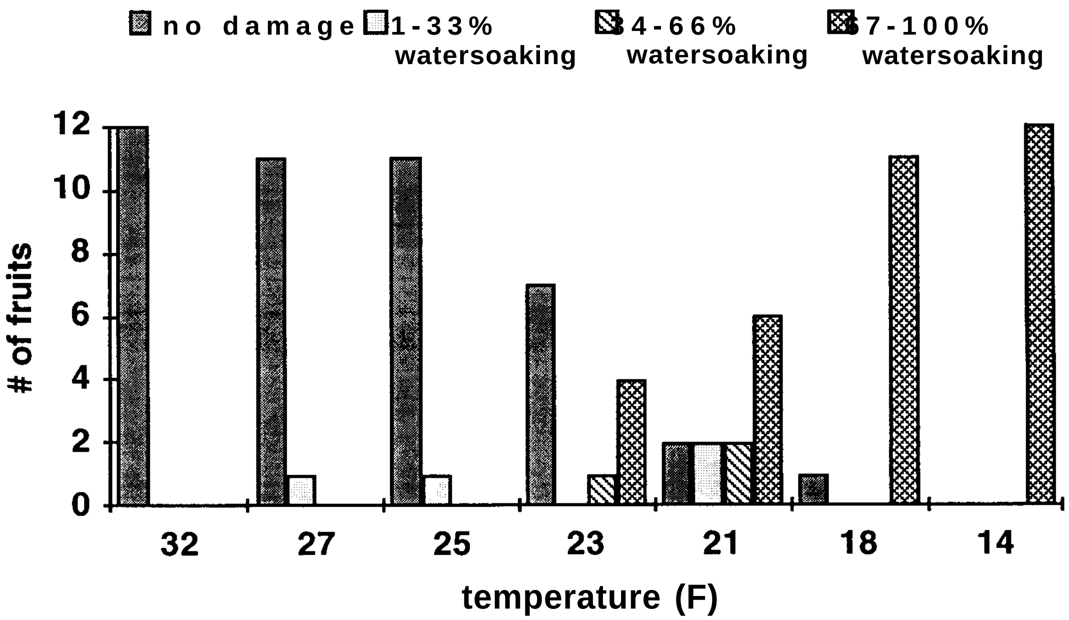

Figure 4. Severity of freezing damage to cranberry fruits <50% blush. A total of 12 fruits was tested at each temperature. Sample was collected on 9/17/97.

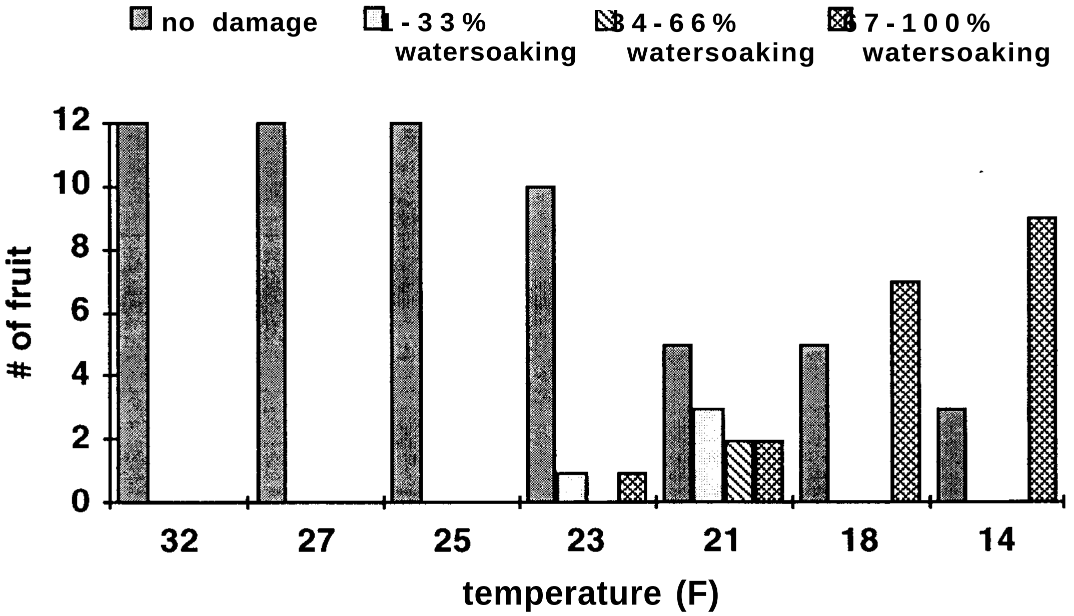

Figure 5. Severity of freezing damage to cranberry fruits >50% blush. A total of 12 fruits was tested at each temperature. Sample was collected on 9/17/97.

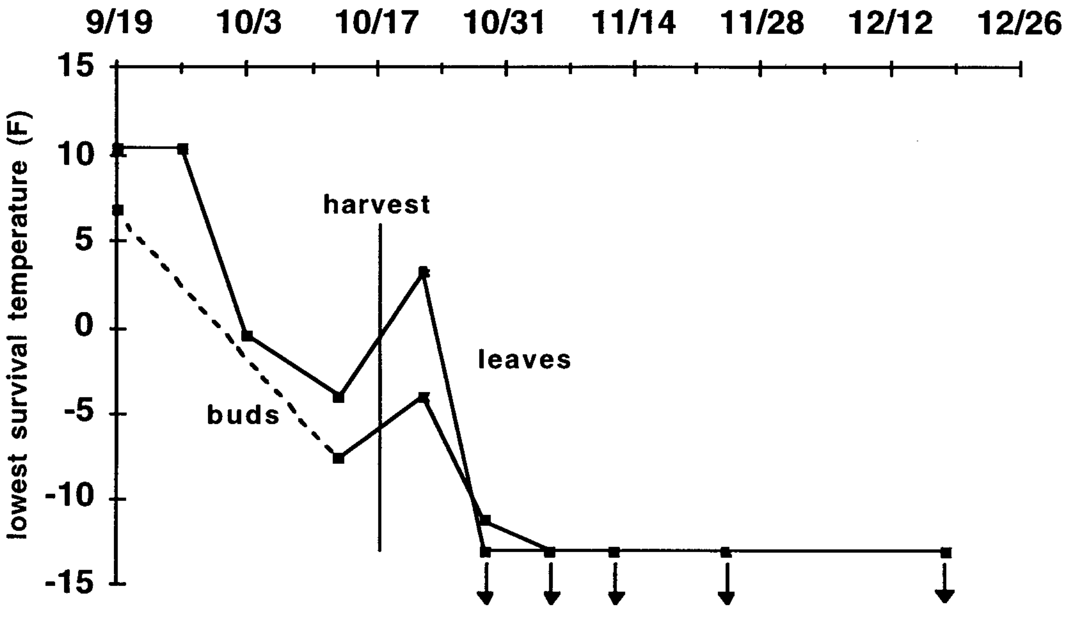

Figure 6. Lowest survival temperatures of terminal buds and leaves from samples collected in the fall of 1996.