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Freeze Susceptibility to Fruit Buds of Selected Apple Cultivars in East-Central Ontario, 1986

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Abstract

Freeze damage to apple fruit buds was assessed at the Smithfield Experimental Farm and in 14 commercial orchards in east-central Ontario following spring frosts in 1986, of -4.5°C at the 13 mm green stage and -4.0°C at the pink stage of bud development. Apple cultivars differed in bud hardiness during the two frosts. 'Idared' had the least amount of bud injury during the first frost but did not differ from 'McIntosh' during the second frost. 'Delicious' buds had more freeze injury than 'McIntosh' during the second frost but there was no difference in bud hardiness between the two cultivars during the first frost. Bud injury during both frosts was greater than expected based on previously reported critical temperature threshold values.

Introduction

Average temperatures during the spring of 1986 were above normal in the Trenton and surrounding area. At the Smithfield Experimental Farm (SEF), mean monthly temperatures during April and May, 1986 were 9.2 and 14.0°C as compared to the 37 year mean (1949 to 1985) of 6.0 and 11.8°C, respectively. Apple bud development therefore was advanced. At the SEF, frosts and freezing temperatures on April 21-23 and on May 2-4 (Table 1) caused considerable damage to developing apple flower buds. Deformation and necrotic blotching of cluster leaves was observed following the May frost.

This paper reports on the relative susceptibility of apple cultivars, at two stages of bud development, to frosts and freeze damage during the spring of 1986. The amount of bud damage observed was compared to critical temperature data from previously reported field and laboratory studies. Of particular interest was flower bud hardiness of 'Empire,' a cultivar new to east-central Ontario.

Materials and Methods

Five flower clusters were selected at random from each of five trees of each cultivar in each orchard to provide a composite sample of 25 clusters. Clusters were selected from approximately 1 to 1.5 m above ground level between May 6 and 14, 1986, when they were at the pink to early bloom stage. Trees of each cultivar in the same orchard were proximate, having a similar microclimate. Individual flower buds were cut longitudinally with a razor blade under a binocular microscope and checked for damage. Flower buds which did not develop past the early tight cluster stage were considered frozen during the April 21-23 frost. Flower buds which developed to or past the pink stage but showed discoloration (browning) to the pistil or ovary were considered frozen during the May 2-4 frost. The total number of flowers was recorded and the resulting percentage of flowers damaged during each period was calculated.

At the SEF, three or four replicate samples (25 clusters per replicate) were collected from four orchards where cultivars were compared in a randomized complete block design. The percentage data were transformed by arcsin and subjected to analyses of variance and Duncan's multiple range test.

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A survey of flower bud damage was conducted in 14 commercial orchards in east-central Ontario. Comparisons between cultivars at each individual site or orchard in the amount of frost damage were made.

Results and Discussion

Apple fruit buds were at the 13 mm green stage of development April 21-23 when the first frost occurred. Individual flowers or complete flower clusters which were killed April 21-23 did not develop past the early tight cluster stage (Figure 1). Severe browning, usually to the whole flower bud, was evident after dissecting injured buds. The uninjured flower buds continued to develop normally until the pink stage (Figure 2) when the second frost occurred, May 2-4. Longitudinal sections through individual flower buds showed considerable browning to the pistil and/or ovary of buds damaged in the May 2-4 frost. Uninjured buds remained green, throughout.

Different survival rates were observed between cultivars during each frost (Table 2). In orchard 1, where four early maturing cultivars were compared, 'Jonamac' had the least amount of blossom damage during the April 21-23 freeze followed by 'Paulared' and 'Jerseymac' with 'Vista Bella' having the most damage. 'Paulared' suffered significantly more bud injury than did 'Jonamac,' 'Jerseymac' or 'Vista Bella' during the May 2-4 frost. Following both freeze events, 'Jonamac' had 48% bud injury, significantly less than 'Jerseymac,' 'Vista Bella' and 'Paulared' with 67%, 69% and 78% injury, respectively.

'Idared' had less flower bud injury than did 'McIntosh' or 'Delicious' during the freeze of April 21-23 even though 'Idared' buds were further advanced (Orchard 2). Freeze damage to 'McIntosh' and 'Delicious' (Orchard 2 and 3) and 'McIntosh' and 'Northern Spy' (Orchard 4) was similar during the April 21-23 frost. 'Delicious' and 'Northern Spy' buds were less advanced than those of 'McIntosh'. During the second frost, May 2-4, of the remaining 'Delicious' flowers, 86% and 89% were injured, significantly higher than the 61% and 73% of the 'McIntosh' flower buds injured in the same orchards. 'Idared', which had only 4% bud injury during the April frost, had 76% injury during the May 2-4 frost.

When flower bud damage from both frosts was totaled, 'Delicious' had the most injury with 92% bud damage. 'McIntosh' had significantly less injury (P=0.05) with 78% to 83% bud damage. 'Idared' and 'Northern Spy,' after both frosts, had 77% and 67% bud damage, respectively, similar to 'McIntosh' in each orchard.

Freeze damage to apple blossoms in commercial orchards surveyed in east-central Ontario is presented in Tables 3-5. Temperature records where

Figure 1. McIntosh flower cluster killed by frost on April 21-21, 1986.

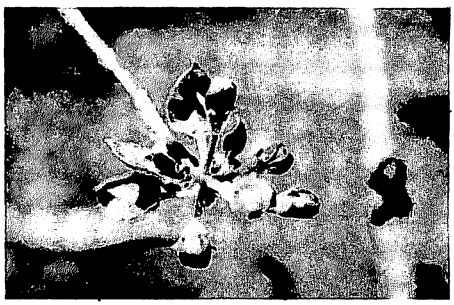

Figure 2. Uninjured McIntosh flower cluster at pink stage, May 9, 1986.

Table 1. Minimum temperature and number of hours below 0°C at Smithfield Experimental Farm during two spring freeze events, 1986.

Stage of bud development and date	Minimum screen temperature (°C)[z]	Number of hours below 0°C
13 mm green		
April 21-22	-4.5	13
April 23	-2.0	6
Pink		
May 2	-1.0	3
May 3	-2.0	4
May 4	-4.0	6

[z]Recorded at 1.5 m height.

available in or near commercial orchards showed similar frost patterns to that recorded at the SEF. Although considerable differences in freeze damage occurred between orchards due to site effects and age of trees, comparisons could still be made between cultivars at each individual site or orchard.

Cultivars in commercial orchards surveyed through east-central Ontario had bud damage patterns similar to that observed at the SEF. Except in orchard 3, 'Idared' suffered less bud damage than did 'Delicious,' 'Empire', 'McIntosh' or 'Spartan' during the April 21-23 frost (Table 3). 'Paulared' had the least amount of bud damage in

Table 2. Freeze damage to apple blossoms at Smithfield Experimental Farm, 1986.

Orchard and cultivar	Rootstock	Tree age (years)	Percent Blossoms injured		
			Apr. 21-23	May 2-4	Both frosts
Orchard 1 (4 reps)					
Jonamac	M26	4	12 a[z]	40 a	48 a
Jerseymac	M26	4	44 c	41 a	67 b
Vista Bella	M26	4	57 d	28 a	69 b
Paulared	M26	4	29 b	71 b	78 b
Orchard 2 (3 reps)					
Idared	MM106	12	4 a	76 a	77 a
McIntosh	MM106	12	36 b	73 a	83 a
Delicious	MM111	12	34 b	89 b	92 b
Orchard 3 (3 reps)					
McIntosh	MM106	16	44 a	61 a	78 a
Delicious	MM106	16	41 a	86 b	92 b
Orchard 4 (3 reps)					
Northern Spy	M26	16	36 a	53 a	67 a
McIntosh	M26	16	20 a	76 a	81 a

[z]Means followed by the same letter within each column for each orchard not significantly different using Duncan's multiple range test, P = 0.05. Data were analyzed after arcsin transformation.

orchard 3. 'Delicious' buds generally had the greatest amount of freeze damage during the May 2-4 frost (Table 4) and overall through both frosts (Table 5) when compared to other cultivars. Orchards 10 and 13 had less total freeze damage to 'Delicious' than to 'McIntosh.' These two orchards were near the Lake Ontario shore and were later in bud development than other orchards in the Waupoose, Trenton or Brighton areas. 'Delicious' buds may have been hardier due to their slower development in these two orchards. The Bowmanville orchard was 3 to 4 days behind the SEF in bud development. This probably explained the lower level of bud damage when compared to orchards in the Trenton, Brighton and Waupoose areas.

In New York state (personal communication) and Massachusetts (1), 'Empire' is considered susceptible to frost injury. In this study, 'Empire' had less bud injury than 'Delicious' except in orchards 10 and 13. Bud development of 'Empire' was slightly ahead of 'Delicious.'

Proebsting and Mills (2) reported a critical temperature threshold for 10% bud kill (T10) for 'Delicious' of -5.6°C and a T50 value of -8.6°C at the 13 mm green stage. 'Delicious' had 34% and 41% bud kill at the SEF after exposure to a minimum temperature of -4.5°C. The amount of damage observed on 'Delicious,' 'Empire,' 'McIntosh' and 'Spartan' at the SEF was greater than expected based on the critical values Proebsting and Mills (2) reported. This difference may be due

Table 3. Freeze damage to apple blossoms in east-central Ontario April 21-23, 1986.

Location and orchard no.	Rootstock	Tree age (years)	Cultivar					
			Delicious	Empire	McIntosh	Idared	Spartan	Paulared
			Percent blossoms injured					
Brighton area								
1	MM106	11	48.4	24.5		9.0		
2	M26	8	31.7		15.8	1.4	39.8	
3	M26	6	20.0		8.3	12.4		3.8
Trenton area								
4	M26	7	23,6	19.1	40.0	0		
5	MM106	16	48.0			4.2		
6	MM106	15	52.6		55.4		60.0	
7	MM106	11		66.7	49.2	5.1		
8	MM106	12	38.0	33.5				
9	M2	17				2.7		
9	MM106	17					66.7	
Waupoose area								
10	M9	11	25.8	18.3	50.3			
11	M26	10		25.4	43.0	8.3		
12	M26	12	53.6	47.7	58.4		50.4	
13	M26	11	16.1	15.3	51.1			
13	MM106	11				3.5		
Bowmanville area								
14	M26	12	8.6	5.4				

to the length of time the temperature was below freezing, differences between air temperature and actual bud temperature, nutritional effects and differences between locations even within a small area. Proebsting and Mills (2) also observed 'Delicious' in the field to be more susceptible to freeze damage than average laboratory values on several occasions. 'Idared' suffered little bud damage during the April 21-23 frost in comparison to the other cultivars, even though bud development of 'Idared' was slightly more advanced.

Bud damage of 86% and 89% was observed on 'Delicious' at the pink stage at the SEF following the May 2-4 frost when a minimum temperature of -4.0°C occurred. The amount of injury observed was higher than anticipated based on Proebsting and Mills (2) T50 critical temperature threshold values of -4.4°C and -3.4°C for 'Delicious' at the first pink and full pink stages, respectively. The April 21-23 frost may have predisposed buds to injury for the second frost, as well as considerations mentioned earlier.

This report suggests that there is an interaction in bud susceptibility to freeze injury between cultivars and stage of bud development. For example, 'Idared' buds had less injury than 'McIntosh' at the 13 mm green stage but there was no difference in bud injury between the two cultivars at the pink stage. Differences in stages of bud development may account for some but not all the differences observed in bud hardiness. 'Empire,' a new cultivar for east-central Ontario, appeared slightly less susceptible to flower bud freeze injury than 'Delicious.'

Table 4. Freeze damage to apple blossoms in east-central Ontario May 2-4, 1986.

Location and orchard no.	Rootstock	Tree age (years)	Cultivar					
			Delicious	Empire	McIntosh	Idared	Spartan	Paulared
			Percent blossoms injured					
Brighton area								
1	MM106	11	66.7	48.6		46.2		
2	M26	8	70.2		58.5	48.2	27.3	
3	M26	6	99.0		53.1	56.7		83.5
Trenton area								
4	M26	7	87.4	31.7	33.3	38.1		
5	MM106	16	32.3			35.0		
6	MM106	15	98.1		31.0		86.5	
7	MM106	11		84.1	92.3	96.9		
8	MM106	12	80.2	79.0				
9	M2	17				77.2		
9	MM106	17					46.5	
Waupoose area								
10	M9	11	12.0	16.5	77.3			
11	M26	10		62.3	64.9	93.4		
12	M26	12	86.2	75.0	89.5		68.8	
13	M26	11	44.4	70.5	39.1			
13	MM106	11				52.6		
Bowmanville area								
14	M26	12	43.6	28.1				

Table 5. Freeze damage to apple blossoms in east-central Ontario following frosts April 21-23 and May 2-4, 1986.

Location and orchard no.	Rootstock	Tree age (years)	Cultivar					
			Delicious	Empire	McIntosh	Idared	Spartan	Paulared
			Percent blossoms injured					
Brighton area								
1	MM106	11	82.8	61.2		51.0		
2	M26	8	79.7		65.1	49.0	56.3	
3	M26	6	99.2		57.1	62.0		84.1
Trenton area								
4	M26	7	90.3	44.7	60.0	38.1		
5	MM106	16	64.8			37.8		
6	MM106	15	99.1		82.3		94.6	
7	MM106	11		94.7	96.1	97.1		
8	MM106	12	87.9	86.1				
9	M2	17				77.3		
9	MM106	17					81.9	
Waupoose area								
10	M9	11	34.7	31.7	88.7			
11	M26	10		71.8	80.0	93.9		
12	M26	12	93.6	86.9	95.6		84.5	
13	M26	11	53.4	75.0	70.2			
13	MM106	11				54.2		
Bowmanville area								
14	M26	12	48.4	32.0				

Literature Cited

1. Anderson, J. F. 1986. Cultivars of apple for Massachusetts. Fruit Notes, Mass. Coop. Ext., Univ. of Mass. 51(4):25-26.
2. Proebsting, Jr., E. L. and H. H. Mills. 1978. Low temperature resistance of developing flower buds of six deciduous fruit species. J. Amer. Soc. Hort. Sci. 103: 192-198.

CORRECTION
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