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Winter Injury to Apple Trees, 1993-1994

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Abstract

Following the cold winter of 1993-1994, ninety scab resistant apple cultivars and selections were evaluated for low temperature injury. Injury symptoms ranged from slight dieback of the terminal branches to complete tree death. Twenty-seven cultivars or selections exhibited no terminal dieback injury. Eight exhibited injury that was more severe than 'McIntosh,' 'Empire' or 'Delicious.' Trees of Co-op 28 and O-666 were killed.

Introduction

Cold hardiness of apple cultivars resistant to apple scab, *Venturia inaequalis* (Cke) Wint. (2) is an important factor in determining their adaptability to growing regions within Canada and the northern United States.

Granger (personal communication) has evaluated the survival of scab resistant apple trees in Quebec following a cold temperature of -35C in early February 1993. Scab resistant apples were not planted or not evaluated for winter injury following the earlier severe winter killing freeze events which occurred during the winters of 1933-34 (1) and 1980-81 (3, 4, 5).

In central Ontario, below normal temperatures occurred during January and February 1994 (Table 1). On 23 December 1993 and 16 January 1994, -32C was recorded at the Smithfield Research Farm (S.R.F.) Trenton, Ontario (44° north latitude, 77° 40' west longitude). Although these conditions caused considerable injury to some apple cultivars and selections, the resulting winter injury and tree death was not as severe as reported following the winter of 1980-81 when a minimum temperature of -37C was recorded at the S.R.F. (5).

The objective of this report is to provide field data on the relative cold hardiness of scab resistant apple cultivars and selections following the winter of 1993-94. Selections evaluated are from the Purdue, Rutgers and Illinois (PRI) breeding program (Co-op selections), New York State Agriculture Experiment Station, Geneva, N.Y. (NY selections), Agriculture and Agri-Food Canada programs at St. Jean, Quebec (FRA selections), Ottawa, Ontario (O selections) and Kentville, N.S. (S selections).

Materials and Methods

Low temperature injury was assessed in three plantings at the S.R.F. that contained scab resistant apple cultivars and selections. Planting one consisted of three trees (not randomized) of a cultivar or selection on each of M.26 and Ottawa 3 rootstock and two trees on MM.106 rootstock. Trees on M.26 and Ottawa 3 rootstock were spaced at 2.5 x 4 m and on MM.106 at 4 x 7 m. Planting two consisted of two trees of a cultivar or selection on Antonovka seedling rootstock spaced at 1.8 x 6.1 m and planting three consisted of two trees on Ottawa 3 rootstock spaced at 2.0 x 4.9 m. Tree age varied from 1 to 16 years. Since some cultivars were not present on all rootstocks, the data is shown separately for each rootstock. Due to the confounded nature of this experiment, the influence of tree age and rootstock on low temperature injury was not determined.

Winter injury was also assessed in an adjacent orchard block containing 9 year-old trees of 'McIntosh,' 'Empire' and 'Delicious' on M.26 rootstock spaced at 2.5 x 6.0 m.

During late May or early June, 1994, a visual assessment of low temperature

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injury for each tree was made using the International Board for Plant Genetic Resources (IBPGR) low temperature injury rating scale.

1 = extremely hardy (no visible dieback)
3 = hardy (slight dieback, end of branch flagging)
5 = intermediate (10 to 25% dieback)
7 = tender (25 to 50% dieback)
9 = extremely tender (>50% dieback)

The mean low temperature injury rating for each rootstock and overall mean rating is presented for each cultivar or selection (Table 2).

Results and Discussion

During the spring of 1994, low temperature injury symptoms ranged from slight dieback of the terminal branches (rating of 3) to complete tree death (rating of 9). Extremely hardy cultivars showed no visible dieback. Of the 90 cultivars and selections rated, 27 were extremely hardy (rating of 1) and showed no visible dieback (Table 2). Fifty-six cultivars or selections were classed as hardy with mean injury ratings from 1 to 3. These cultivars exhibited only slight terminal dieback. Four cultivars or selections ('Jonafree,' Co-op 7, Co-op 20 and O-661) exhibited 10 to 25% dieback and were classed as intermediate in hardiness with mean injury ratings from 3.6 to 5. Three selections (Co-op 25, Co-op 28 and O-666) were rated as tender with mean injury ratings above 5. Trees of Co-op 28 and O-666 were killed.

Table 1. Minimum monthly temperatures, and 44 year mean minimum monthly temperatures at the Smithfield Research Farm, Trenton, Ontario (°C).

Month	Minimum 1993-94	44 Year mean minimum
October	-4.8	4.0
November	-13.0	-0.7
December	-32.0	-8.4
January	-31.8	-11.5
February	-25.5	-10.6
March	-13.5	-5.4

Table 3. Mean low temperature injury ratings of 9-year-old trees planted at the Smithfield Research Farm, Trenton, Ontario.

Cultivar	Number of trees	Injury rating[y]
McIntosh	79	2.6a[z]
Delicious	80	1.8b
Empire	82	1.5b

[y]Rating scale:
1 = extremely hardy (no visible dieback)
3 = hardy (slight dieback, end of branch flagging)
[z]Means separation using Duncans multiple range test ($P < 0.05$).

'McIntosh' is generally considered more winter hardy than 'Empire' or 'Delicious' (4, 5), contrary to the results reported here (Table 3). Above normal rainfall during September and October, 1993 (154% of normal) may have contributed to a lack of hardening off of 'McIntosh' in the fall of 1993 which resulted in greater dieback injury compared to 'Empire' or 'Delicious.' Scab resistant cultivars or selections with injury ratings of 3 or above may be considered less hardy than 'McIntosh,' 'Empire' or 'Delicious.' These include (injury rating in brackets) 'Jonafree' [4.2], Co-op 7 [4.0], Co-op 20 [3.6], Co-op 25 [5.6], Co-op 28 [9.0], O-6413 [3.0], O-661 [4.3] and O-666 [7.9].

Tree survival counts were made by Granger (personal communication) in Quebec following a cold temperature of -35C on 6-7 February 1993. The scab resistant cultivars and selections which survived without damage in Quebec were 'Murray,' 'Novamac,' FAR110A010 and O-637. In the present study, these cultivars had mean injury ratings of 1 to 1.5 with no or slight dieback. Six cultivars or selections classed as tender by Granger had injury ratings of 1.2 to 4.2 (injury rating shown in brackets). These were 'Free-

Table 2. Mean low temprature injury ratings[y] of scab resistant apple cultivars and selections planted since 1978 at the Smithfield Research Farm, Trenton, Ontario.

Cultivar or selection	Antonovka		Ottawa 3		M.26		MM.106		All rootstocks	
	No of trees	Mean injury rating	No. of trees	Mean injury rating	No. of trees	Mean injury rating	No. of trees	Mean injury rating	No. of trees	Mean injury rating
Dayton			3 (5)[z]	1.3	6 (3)	1.2	2 (3)	1.0	11	1.2
Florina Querina			3 (3)	1.0	3 (1)	1.0	2 (1)	2.0	8	1.3
Freedom					2 (4)	1.5	2 (8)	1.5	4	1.5
Jonafree			2 (11)	3.5	3 (9)	5.3	1 (11)	2.0	6	4.2
Macfree	3 (4)	3.3	5 (10)	1.0	3 (16)	3.3	2 (16)	1.0	13	2.1
McShay					3 (1)	1.3			3	1.3
Moira	2 (1)	2.0	3 (16)	1.0	3 (16)	3.0	2 (16)	1.0	10	1.8
Murray	3 (4)	1.0	3 (4)	1.0	2 (16)	1.0	2 (16)	1.0	10	1.0
Nova Easygro	3 (3)	1.3	3 (10)	1.0	2 (8)	1.0	2 (11)	1.0	10	1.1
Novamac	2 (2)	1.0	3 (11)	1.0	3 (8)	1.0	2 (11)	1.0	10	1.0
Novaspy	2 (2)	1.0	3 (4)	3.3	3 (5)	2.3	2 (5)	1.0	10	2.1
Redfree			3 (9)	1.0	3 (11)	1.0	2 (13)	1.0	8	1.0
Richelieu	2 (1)	2.0	3 (16)	1.3	3 (16)	1.0	2 (16)	1.5	10	1.4
Rouville	2 (1)	2.5	3 (9)	1.0	3 (8)	1.0	2 (9)	1.0	10	1.3
Trent	3 (4)	4.3	5 (10)	1.4	3 (14)	1.3	2 (16)	1.0	13	2.0
William's Pride			3 (5)	1.7	6 (3)	2.5	2 (5)	1.0	11	2.0
CBR4T29			3 (2)	2.7	3 (3)	2.7	2 (2)	1.0	8	2.3
Co-op 6							1 (16)	1.0	1	1.0
Co-op 7							2 (10)	4.0	2	4.0
Co-op 8							2 (13)	1.5	2	1.5
Co-op 9							2 (13)	1.0	2	1.0
Co-op 10							2 (13)	1.0	2	1.0
Co-op 11							2 (12)	1.0	2	1.0
Co-op 12							2 (8)	1.5	2	1.5
Co-op 14							2 (13)	1.0	2	1.0
Co-op 15							2 (8)	1.0	2	1.0
Co-op 16							2 (13)	1.0	2	1.0
Co-op 17							2 (16)	2.0	2	2.0
Co-op 19			3 (4)	1.0	2 (5)	1.5	1 (5)	1.0	6	1.2
Co-op 20			3 (5)	2.7	3 (5)	5.7	2 (3)	2.0	8	3.6
Co-op 24			3 (3)	2.3	3 (5)	2.0	2 (5)	1.0	8	1.9
Co-op 25			3 (1)	3.7	3 (1)	7.7	2 (5)	5.5	8	5.6
Co-op 26			3 (5)	2.0	3 (4)	2.3	2 (3)	1.0	8	1.9
Co-op 27					3 (1)	1.0			3	1.0
Co-op 28					2 (1)	9.0			2	9.0
Co-op 29					1 (1)	1.0			1	1.0
Co-op 30					3 (1)	1.3			3	1.3
Co-op 31					3 (1)	1.7			3	1.7
FAR 006A013			3 (3)	1.0	3 (4)	1.0	2 (4)	1.0	8	1.0
FAR 026A021							2 (4)	1.0	2	1.0
FAR 026A042			2 (2)	1.0	3 (4)	1.3	2 (3)	1.5	7	1.3
FAR 035A005			3 (4)	1.0	3 (3)	1.0	2 (2)	1.0	8	1.0
FAR 054A024			3 (2)	1.3	3 (4)	1.0	2 (3)	1.0	8	1.1
FAR 054A048			3 (3)	1.0	3 (4)	1.0	2 (4)	1.0	8	1.0
FAR 086A037					3 (3)	2.0	2 (3)	1.0	5	1.6
FAR 094A042			2 (2)	1.5	3 (4)	1.7	2 (2)	1.0	7	1.4

Table 2. (Continued).

Cultivar or selection	Antonovka		Ottawa 3		M.26		MM.106		All rootstocks	
	No of trees	Mean injury rating	No. of trees	Mean injury rating	No. of trees	Mean injury rating	No. of trees	Mean injury rating	No. of trees	Mean injury rating
FAR 095A007			3 (2)	1.7	3 (4)	2.3	2 (4)	1.0	8	1.8
FAR 110A10			3 (2)	1.3	3 (4)	1.0	2 (2)	1.5	8	1.2
NY65707-19			3 (3)	1.0	3 (3)	2.0	2 (3)	2.0	8	1.6
NY66305-139			3 (3)	1.3	3 (3)	1.3	2 (3)	1.0	8	1.2
NY66305-289			3 (3)	1.0	3 (3)	1.3			6	1.2
NY66325-139			3 (3)	1.7	3 (3)	2.0	2 (3)	1.0	8	1.6
NY73334-35			3 (3)	1.0	3 (3)	2.0	2 (3)	1.0	8	1.4
NY74828-12			3 (3)	1.0	3 (3)	2.0	2 (3)	1.0	8	1.0
NY74840-1			3 (3)	1.3	3 (3)	1.7	2 (3)	1.0	8	1.4
NY75414-1			3 (3)	1.0	3 (3)	1.0	2 (3)	1.0	8	1.0
NY75441-67			3 (3)	1.7	3 (3)	1.3	2 (4)	1.0	8	1.4
O-521	2 (1)	1.0							2	1.0
O-5210			2 (3)	1.0					2	1.0
O-533							2 (10)	1.0	2	1.0
O-546	2 (2)	2.0	2 (3)	1.0			2 (13)	1.0	6	1.3
O-5410							2 (10)	1.0	2	1.0
O-5412							2 (10)	2.0	2	2.0
O-564	2 (2)	1.5					2 (4)	1.0	4	1.3
O-634	2 (2)	2.0					2 (16)	1.0	4	1.5
O-637	2 (2)	2.0	3 (11)	1.3	2 (14)	1.0	2 (16)	2.0	9	1.5
O-641	2 (2)	2.0					1 (13)	1.0	3	1.7
O-645							2 (16)	1.0	2	1.0
O-649							2 (8)	1.5	2	1.5
O-6412	2 (2)	1.5	3 (9)	1.0	3 (9)	1.0	2 (8)	1.0	10	1.1
O-6413	2 (2)	4.5					2 (16)	1.5	4	3.0
O-6420			3 (9)	1.0	2 (10)	1.5	2 (10)	1.0	7	1.1
O-6421			3 (10)	1.0	3 (9)	1.0	2 (10)	1.0	8	1.0
O-6422	2 (1)	1.0	3 (10)	1.3	3 (10)	1.0	2 (10)	1.0	10	1.1
O-654	2 (2)	4.0					2 (11)	1.5	4	2.8
O-658	2 (1)	2.0	3 (8)	1.0			2 (8)	1.5	7	1.4
O-659			3 (5)	1.0	2 (5)	1.0	2 (5)	1.0	7	1.0
O-661	2 (2)	6.0					2 (13)	2.5	4	4.3
O-662	2 (2)	1.0	3 (10)	1.0	3 (12)	1.7	2 (10)	1.0	10	1.2
O-664	2 (2)	2.5					2 (8)	2.5	4	2.5
O-665	2 (1)	3.5	3 (9)	3.0	3 (6)	1.0	2 (5)	1.0	10	2.1
O-666			2 (9)	9.0	3 (8)	9.0	2 (8)	5.0	7	7.9
O-669			3 (9)	1.0	3 (10)	1.0	2 (10)	1.0	8	1.0
O-6615			3 (4)	1.0	3 (4)	1.0	2 (5)	1.5	8	1.1
O-6616	2 (1)	3.0	2 (4)	1.5	3 (5)	1.3	2 (5)	1.5	9	1.8
O-6617	2 (1)	2.0					2 (5)	1.0	4	1.5
O-6618			3 (5)	1.0	2 (5)	1.0	2 (5)	1.0	7	1.0
O-6619			3 (5)	1.0	3 (5)	1.0	2 (5)	5.5	8	2.1
S34-22-49			3 (5)	1.0	3 (5)	1.3	2 (5)	1.0	8	1.1
S47-25-52			3 (5)	1.3	3 (5)	2.0	2 (5)	1.0	8	1.5

[y]Rating scale:
1 = extremely hardy (no visible dieback)
3 = hardy (slight dieback, end of branch flagging)
5 = intermediate (10 to 25% dieback)
7 = tender (25 to 50% dieback)
9 = extremely tender (>50% dieback)

[z]Value in parentheses indicates tree age.

dom' [1.5], 'Jonafree' [4.2], 'Macfree' [2.1], 'Nova Spy' [2.1], CBR4T29 [2.3] and O-662 [1.2]. Cultivars and selections classed as moderately cold tolerant were 'Rouville' [1.3], 'Trent' [2.0], FAR006A013 [1], O-533 [1], O-5410 [1], and O-654 [2.8].

This report is based on one year's observations. It is recognized that a number of different factors affect the cold hardiness of cultivars. These observations should be useful in comparing the relative cold hardiness of scab resistant cultivars and selections. By comparing their hardiness to the standard cultivars 'McIntosh,' 'Empire' and 'Delicious,' one can predict the likelihood of survival over the long term in various growing regions.

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Viability of Different Pear Pollen and the Effect on Fruit Set of 'Anjou' Pear (*Pyrus communis* L.)

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Abstract

'Anjou' flowers were hand pollinated from 12 different varieties of pears during 1990, 1991 and 1993. There was a wide range in the bloom period of the different cultivars. 'Eldorado' and 'Bosc' pollen had the best viability. Pollen from 'Bartlett,' *Pyrus calleryana* and 'Nijissecki' induced the most fruit set in 1990; however, there was no difference in 1991 or 1993. By hand pollinating, no relation was seen between pollen viability and fruit set. It is suggested that for best fruit set in 'Anjou' orchards, hand pollination should be practiced and/or the orchards should have at least 3 pollenizer varieties covering 'Anjou' bloom period. Seed numbers were highest in fruit that had been pollinated with pollen from 'Old Home' x 'Farmingdale' (OH x F) 333 and OH x F 69. Fruit size was different only in 1991 when the largest was from flowers receiving pollen from 'Nijissecki,' 'Anjou' or OH x F 333. Fruit size was not related to seed number. No differences were found in quality studies including firmness, soluble solids, internal color, external color and titratable acidity which shows that metaxenia does not exist in 'Anjou' pears.

Production instability due to inconsistent fruit set is a major problem in pear production. This is especially true for the variety 'Beurre d'Anjou,' *Pyrus communis* L. The presence of many flowers on 'Anjou' pear in the spring is quite evident but a very low percentage of these flowers set fruit. Pollination is a problem in setting 'Anjou' fruit. Many pears cultivars are not self-fruitful, one of which is 'Anjou.' The bloom period for many pear cultivars does not correspond with that of 'Anjou.' Some varieties have pollen with poor germination and poor pollen tube growth. A desirable pollenizing variety would be one with a high rate of pollen viability and a bloom date corresponding to that of 'Anjou.'

Nebel (2) indicated that metaxenia, defined as the physiological effect of