Winter Injury to Apple Trees, 1980-1981

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Serious winter injury and tree losses occurred to apple cultivars in eastern Ontario and Quebec following the winter of 1980-81. On December 24, 1980, a rapid drop in temperatures from −9°C to −28°C over a 16 hr. period occurred at the Smithfield Experimental Farm (S.E.F.), Trenton, Ontario. Further, a 30 year record low temperature of −37°C was recorded on January 4, 1981. Below normal temperatures continued through January (Table 1). Above normal temperatures in February and March resulted in an early spring. Frosts occurred on April 19 (−6°C), 21 (−5°C) and 22 (−4°C) when McIntosh buds were at the 12 mm green stage.

Table 1. Mean monthly temperautres, S.E.F. (°C).

Month	1980-81	30 Yr average
September	15.2	14.9
October	7.7	9.0
November	1.7	3.1
December	−7.6	−4.4
January	−11.6	−7.5
February	−1.2	−3.1
March	1.0	−1.4
April	7.3	6.1

When the most advanced flower buds were at the tight cluster stage, an assessment was made of damage throughout the area by taking counts on a minimum of 50 flower clusters per tree. Cluster samples from two to four trees were counted in various orchards. The flower clusters were rated as having made normal growth, injured (flower buds showing green but exhibiting reduced growth), and dead (flower buds with no green tissue). A flower cluster hardiness rating was devloped and was calculated as follows % normal clusters × 3 plus % injured clusters × 2 plus % dead clusters × 1.

Hardiness ratings were also determined for single trees of various cultivars growing on *Malus robusta* 5 and Ottawa 3 rootstocks in a 6-9 year old bearing, cultivar evaluation orchard at the S.E.F. The number of clusters which flowered and produced fruit was also recorded. At harvest 10 fruit per tree were selected at random from each strain of McIntosh and Delicious growing in the orchard. Fruit shape was rated using a scale of 1 to 5 (1 = no deformity, 5 = extreme deformity) (1). The number of mature seeds per fruit was also counted.

Results and Discussion

Following the cold period of December and early January extensive blackheart injury was evident in the twigs and spur wood of many fruit cultivars. Some bark splitting on trunks was noted. Tip dieback of twigs, especially on young or late growing plantings was evident. Spring bud development on winter injured cultivars was slower than normal and considerable variation in bud development occurred. As the season progressed bark cracking and shrinking became evident in the crotch areas, on the trunk, scaffold limbs or anywhere up the trees. Bark, cambium or tree death occurred in some instances. Scald injury to the bark was also common. Other symptoms noted during the growing season included pale foliage colour, heavy June drop, bleeding from pruning cuts, deformed fruit, and small seedless fruit.

Where cultivars were compared at more than one location, McIntosh and Idared were rated as the hardiest (Table 2). On the average, 75% of

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Table 2. Flower cluster hardiness assessment of apple cultivars at various locations.

Cultivar	No. of samples	Average % of flower clusters			Average[1] hardiness rating
		Normal	Injured	Dead	
McIntosh	13	74.5	15.5	10.0	265
Idared	7	75.4	12.1	12.5	263
Spartan	3	65.1	15.6	19.3	246
Empire	2	55.5	17.6	26.9	229
N. Spy	2	45.9	16.8	37.3	209
Mutsu	2	25.2	46.5	28.3	197
Delicious	22	37.4	20.7	41.9	196

[1]Hardiness rating = (% normal × 3) + (% injured × 2) + (% dead × 1).

Table 3. Flower cluster hardiness assessment of apple cultivars at S.E.F.

Cultivar[1]	Average % of flower clusters			Average[2] hardiness rating
	Normal	Injured	Dead	
Puritan	96.1	3.9	0	296
Viking	94.1	4.4	1.5	293
Honeygold	92.2	7.8	0	292
Scotia	87.7	12.3	0	288
Loyalist	83.5	14.9	1.7	282
Summerred	82.7	15.4	1.9	281
G. Russet	85.8	8.5	5.7	280
Julyred	81.4	14.7	3.9	278
McIntosh[3]	76.4	20.1	3.4	273
Idared	75.0	17.3	7.7	267
Lindel	67.5	29.4	3.2	264
Chieftan	61.3	34.3	4.3	257
Paulared	54.3	41.3	4.3	250
N. Spy	67.9	13.2	18.9	249
Jonnee	54.5	34.8	10.6	244
Delicious[4]	47.0	23.0	30.0	217
Mutsu	45.6	23.7	30.7	215
R.I. Greening	44.0	0	56.0	188
Sinta	26.8	28.5	44.7	182
Sundale G. Del.	15.9	34.8	49.3	167

[2]Hardiness rating = (% Normal × 3) + (% Injured × 2) + (% Dead × 1).
[1]Trees 6-9 years old.
[3]Average of 6 strains.
[4]Average of 12 strains.

their flower clusters showed normal bud growth while 10 and 12.5% respectively, showed no green tissue development. Average hardiness ratings of 265 and 263 were calculated for McIntosh and Idared. By contrast, Mutsu and Delicious had the lowest average hardiness ratings of 197 and 196 respectively. Twenty-five and 37% of the Mutsu and Delicious flower clusters had normal bud growth, while 28 and 42% showed no growth.

There were no consistent differences in the hardiness rating of cultivars growing on the vigorous *M. robusta* 5, in comparison to those on the size-controlling Ottawa 3 rootstocks. Many of the early maturing cultivars (Puritan, Viking, Scotia, Summerred, Julyred) were as hardy or hardier than McIntosh (Table 3). This was likely due to improved hardening off in the fall associated with early harvesting, as compared to cultivars which were picked later than McIntosh. Tree damage and death reported by growers agreed closely with the hardiness ratings used in this report. A survey of orchards in Northumberland and Prince Edward counties (unpublished)

Table 4. Performance of Delicious and McIntosh strains at the S.E.F. following the test winter of 1980-81.

Cultivar	Hardiness rating	% of total clusters with			Shape rating[3]	Seed count
		Normal growth	Flowers	Fruit[2]		
Delicious strains[1]						
Red Queen	263	70	85	50	2.5	2.7
Chelan	246	65	83	67	2.4	2.4
Topred	226	45	77	51	2.2	4.4
Royal Red	212	44	58	20	—	—
Red Prince	207	38	69	26	2.7	3.6
Ave. Non-spur Types	231	52	74	43	2.4	3.3
Redspur	244	64	77	66	3.2	4.7
Redchief	225	54	69	52	2.5	5.9
Starkcrimson	221	44	76	61	3.0	5.9
Millerspur	203	45	61	52	3.0	5.0
Sturdeespur	187	37	47	32	—	—
Skyspur	176	28	45	38	2.3	5.8
Bisbee	173	28	41	35	2.4	6.8
Ave. Spur Types	204	43	59	48	2.7	5.7
McIntosh strains[1]						
Macspur	283	85	94	85	1.9	5.4
VC309[4]	282	83	99	91	1.8	6.6
Geneva	278	81	95	87	1.6	4.7
Imperial	271	73	95	88	1.6	4.8
Historical[4]	265	71	93	92	1.4	6.8
Starkspur	261	67	94	93	1.9	4.9

[1]Trees 6 to 9 years old.
[2]Fruit set assessment 16 days after full bloom.
[3]Shape rating 1-5; 1 = no deformity, 5 = extreme deformity.
[4]Virus tested.

showed that the most serious tree losses were of R.I. Greening, Spy and Delicious. Cortland, Idared, Spartan, Empire and cultivars maturing earlier than McIntosh had less tree losses than McIntosh.

Spur type Delicious, on the average, had a lower hardiness rating than non-spur strains (Table 4). The spur type strains also had a lower percentage of the clusters with flowers, however a larger percentage of those flowering set fruit. There was little difference in the percent of total clusters with fruit 16 days after full bloom. There was a tendency for some spur type strains to have a poorer fruit shape rating at harvest than non-spur strains.

Table 5. Hardiness, fruit set and yield efficiency of apple cultivars growing on *Malus robusta* 5 rootstock following the test winter of 1980-81.

Cultivar[1]	Hardiness rating	% of total clusters		Yield efficiency (kg/cm²)
		Normal growth	With fruit[2]	
McIntosh strains				
Macspur	281	84	85	.85
VC309	278	80	88	1.27
Geneva	279	79	89	1.04
Imperial	275	75	100	.83
Historical	268	71	84	.98
Starkspur	251	59	95	.59
Delicious strains				
Red Queen	285	85	56	.54
Chelan	246	65	67	.82
Redspur	240	66	52	.09
Red Prince	231	57	12	.06
Starkcrimson	223	45	50	.50
Royal Red	212	44	20	.14
Topred	202	22	47	.31
Bisbee	173	28	35	.15
Millerspur	161	25	31	.35
Skyspur	143	12	18	.27
Other cultivars				
Puritan	296	96	84	.48
G. Russet	293	93	81	.49
Loyalist	282	85	87	.53
Lindel	277	77	77	1.56
Idared	264	71	60	.43
Chieftan	257	61	40	.62
N. Spy	249	68	60	.32
Sinta	221	35	67	.34
Mutsu	193	33	4	.07
Sundale G. Del.	167	16	55	.36

[1]Trees 6-9 years old.
[2]Fruit set assessment 16 days after full bloom.

It was surprising, however, that the seed count was higher in the spur type strains than in the non-spur strains. Perhaps with the spur type strains, the weaker fruit buds were eliminated resulting in a higher percent set and seed count in the remaining fruit.

McIntosh strains were also compared. Macspur and Starkspur McIntosh had the poorest fruit shape rating of the McIntosh strains compared (Table 4); however, these differences were not significant at the 5% level. VC309 and the Historical McIntosh (virus tested) had significantly higher seed counts than the other strains.

There was a fair correlation ($r = .6^{**}$) between the hardiness rating and 1981 yield expressed as kg of fruit per cm^2 trunk cross-sectional area (Table 5). The percent of total clusters with fruit showed a similar correlation. Some cultviars such as Delicious and Mutsu had yields lower than can be explained simply by the flower cluster hardiness rating. These cultivars had a lower fruit set than others. The yield therefore was related not only to the hardiness rating but also to the ability of the flower clusters to set fruit.

This report is based on one year's observations. It is recognized that there are a number of different factors which affect winter hardiness and that the expression of injury may occur in many different forms. These observations should prove useful in comparing the relative winter hardiness of cultivars following conditions similar to those occurring during the winter of 1980-81.

Literature Cited

1. Proctor, J. T. A. and E. C. Lougheed. 1980. A deformity of apples of unknown origin. Can. Plant Dis. Surv. 60:13-16.

Apple Rootstock and Density Trials

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Current production techniques of most fruit and row crops utilize higher plant densities than those used 25 to 50 years ago. Higher densities usually produce higher yields per acre with lower production costs per volume of yield. Mechanical and cultural technology have made higher crop densities feasible. Apple trees have usually been grown at rather low densities of 30 to 50 per acre, but development of size controlling rootstocks has favored higher densities. Experiments are in progress evaluating densities of thousands of trees per acre with an interest in complete mechanization including harvest (1, 2).

Dwarfing and semi-dwarfing rootstocks are presently used widely in the United States, but many problems have occurred including poor root anchorage, disease susceptibility, and lack of hardiness (2, 3, 4, 7, 8). In Tennessee tests (5), M 9 and M 26, the more dwarfing rootstocks, failed to survive more than 5 to 7 years. Trees on M 7 had problems with breakage at the graft union and had weak root

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