Centre de référence en agriculture et agroalimentaire du Québec

RECUPOM

Introductory level Quebec Apple Cultivars and Rootstocks Evaluation Project

Cultivar trials, 1997-2003, 1998-2004 and 1999-2005
Rootstock trials, 1996-2005, 1997-2005, 1998-2005

Fédération des producteurs de pommes du Québec
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Quebec Apple Cultivars and Rootstocks Evaluation Project

Final report

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Canada

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Acknowledgements

We extend our thanks to the employees of the Frelighsburg Experimental Farm.

Introduction

The Quebec Cultivars and Rootstocks Evaluation Project was executed under the auspices of the RECUPOM network, introductory level. The experimental plots are located at Agriculture and Agri-Food Canada's Experimental Farm in Frelighsburg, in southern Quebec (longitude 72º50' W, latitude 45º3' N), 1 km from the northwestern border of the state of Vermont, in the United States. The topography is undulating, while the soil is a sandy loam derived from shale materials, containing a large number of stones and large pebbles. The elevation is 205 m. The mean minimum winter temperature (i.e. the mean value for minimum temperatures between January 1 and March 31) in Frelighsburg during the period 1998-2005 was -24ºC (-28°C in 2003, -17°C in 2002).

Materials and methods

This report presents the results of three cultivar trials and three rootstock trials, with seven cultivars and selections planted in 1997, ten cultivars and selections planted in 1998, twelve cultivars and selections planted in 1999, four rootstocks planted in 1996, eight rootstocks planted in 1997, and two rootstocks planted in 1998.

The cultivars and selections were evaluated under orchard conditions during a period of six years, and the rootstocks during a period of eight to ten years. The cultivar trials included a series of scab-resistant apple varieties and a series of scab-sensitive varieties. The trees were treated differently in terms of fungicide protection: the scab-tolerant varieties received no fungicide treatment apart from one with copper at the beginning of the season, while the scab-sensitive varieties received preventive and eradicant fungicide treatment (Guide des traitements foliaires du pommier, CRAAQ, 1997-2005).

The experimental plot in which the cultivar trials were conducted was a 0.5-ha orchard, oriented north and south. Tree spacing was 2 m within rows, with the rows being 4.5 m apart. The experimental cultivars and selections, grafted on to EM26 rootstock, were replicated five times and planted at random within the plot. A control consisting of five McIntosh Summerland trees on EM26 rootstock was planted at the same time as the experimental trees. McIntosh Summerland/EM26 is well known and widely used in Quebec orchards. It constitutes a good reference and comparison variety. Unfortunately, owing to propagation difficulties, the 1997 and 1999 trials were conducted without any McIntosh controls. The experimental layout used was a completely randomized design.

The test plot in which the rootstock trials were conducted was a 0.40 ha orchard, oriented north and south. Spacing for rootstock trees was 4.5 m by 2 m in the case of dwarf trees, and 5 m by 3 m in the case of semi-dwarf and semi-vigorous varieties. The experimental rootstock trees were grafted with McIntosh Summerland and Spartan cultivars, replicated five times for each cultivar and planted in accordance with a randomized block design.

The experimental plots were fertilized annually in accordance with the recommendations of the CRAAQ Guide de référence en fertilisation, 2nd edition, 1996. The trees were protected from pests in accordance with the recommendations of the CRAAQ Guide de gestion intégrée des ennemis du pommier, 2001. They were thinned manually every year at the 10-12 mm fruit stage. The experimental plots containing the cultivars were not irrigated; those containing the rootstock trees were irrigated by means of a drip system from the spring of 1999 onward. Irrigation periods were determined from tensiometer readings. The trees were trained in accordance with the vertical axis system, with a light winter pruning and a moderate green pruning. No positioning of branches was performed. The support system consisted of a 2-m wooden stake for each tree, with a bracing wire connecting the tops of the stakes.

Tree-related data, such as freezing index, lignification index, suckering rate, incidence of burrknots, flowering index and trunk circumference, were taken every year (see the glossary for definitions of these terms) on the five trees in each treatment.

Every year, the fruit was harvested at maturity, and each tree's production was weighed in the orchard by means of an electronic balance. The weight of 10 fruits selected at random was recorded. Ten fruits per treatment, selected at random, were then used to measure the ripeness index, the pressure index and the sugar index (see glossary) in the laboratory. A sensory assessment of the fruit (appearance and flavour) was conducted at each harvest and the results entered on a data sheet.

Quantitative data, such as trunk circumference, yield, cumulative yield, productivity index and vigour index were calculated and an analysis of variance was performed. The data were analyzed by means of the mixed procedure of the SAS/STAT software, version 8.2 (Copyright 2001 SAS Institute Inc., Cary, NC, USA). Differences between mean values were determined by multiple comparisons generated by the LSMEANS instruction of SAS, at a probability of 0.05.

Cultivar and selection trial, 1997-2003

Descriptions of cultivars and selections (see photographs of the fruits in Appendix 4).

Scarlet Spire
Pink blush over yellowish-green apple, harvest late September, tree columnar.

Emerald Spire
Red apple, harvest early October, tree columnar.

Ottawa 6412 (McIntosh x O-522)
Red-streaked over green apple, harvest early October, good keeper, processing, tree scab-resistant, origin AAFC Smithfield, Ontario.

Ottawa 6413 (O-527 x Lobo)
Cortland-type apple, red-streaked over green, harvest early October, for processing, tree scab-resistant, origin AAFC Smithfield, Ontario.

Ottawa 654 (O-522 x Sandel)
Pink blush over greenish-yellow apple, harvest late September, tree scab-resistant, origin AAFC Smithfield, Ontario.

Ottawa 665 (O-522 x Red Delicious)
Red blush over green apple, harvest early October, good keeper, for processing, tree scab-resistant, origin AAFC Smithfield, Ontario.

Ottawa 662 (O-521 x Red Delicious)
All-season apple, deep red blush over green, harvest early October, good keeper, tree scab-resistant, origin AAFC Smithfield, Ontario.

Results and discussion

The cultivars Emerald Spire and Scarlet Spire are colonnade apple trees, with low vigour and a non-spreading habit. Scarlet Spire proved to be quite cold-sensitive, while very little cold damage was observed in the case of Emerald Spire (Table 1). These two cultivars hardened off late (Table 2). Both of them were low-yielding (Table 3, CY) and were characterized by low productivity (Table 3, CYE). Fruit quality was low (fruit data sheets). Neither cultivar is promising in terms of commercial growing in Quebec.

The Ottawa selections were scab-resistant. These selections were characterized by high (O-665, O-654) to moderate (O-662, O-6412, O-6413) vigour, high (O-6413, O-654) to moderate (O-6412, O-665, O-662) yields, and high (O-6413), moderate (O-662, O-6412, O-654) and low (O-665) productivity (Table 3). These selections proved to be cold-resistant, with slightly less cold damage having been observed for O-654, O-665 and O-6413 than for O-662 and O-6412, and all of them hardened off fairly well (tables 1, 2). Fruit quality was fair to poor, with lack of firmness and high acidity (Appendix 3. Fruit data sheets). The fruit of O-6413 was similar to a sour Cortland with no aroma. O-654 produced large, yellow fruit. Symptoms of soggy breakdown were observed with the fruit of O-6413 (two years out of five) and O-665 (one year

out of five). Of all these selections, O-6413 was the only one that seemed to us to be of some interest for the specialized market or processing, as the tree was productive and the fruit quality fair but acceptable.

Table 1. Annual freezing indices* for cultivars and selections on EM26 rootstock planted in 1997 at AAFC, Frelighsburg

Cultivar	1998	1999	2000	2001	2002	2003
O-6412	5	7	6	7	5	12
O-662	5	8	6	7	7	13
O-654	5	5	6	5	5	8
O-665	5	5	6	5	5	10
O-6413	5	5	6	8	5	8
Emerald Spire	5	5	5	5	5	7
Scarlet Spire	5	5	7	13	5	15

**Sum of indices for 5 trees*

1 = no sign of freezing, 2 = freezing on terminal bud, 3 = necrosis on trunk and small branches, 4 = death of tree

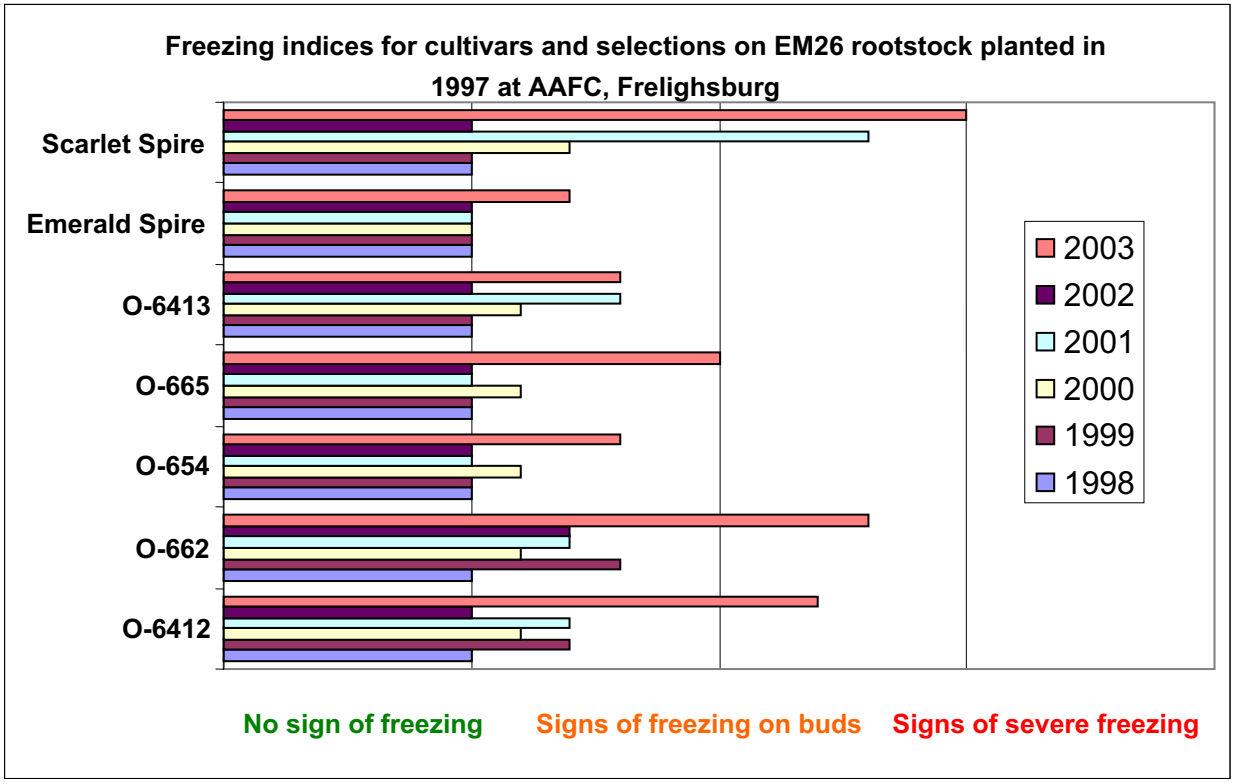


Table 2. Annual lignification indices* for cultivars and selections on EM26 rootstock planted in 1997 at AAFC, Frelighsburg

Cultivar	1997	1998	1999	2000	2001	2002	2003
O-6412	6	9	7	7	6	11	6
O-662	7	9	5	7	6	7	5
O-654	7	7	5	8	5	6	5
O-665	8	8	7	8	6	7	7
O-6413	9	10	5	5	5	10	5
Emerald Spire	9	10	10	11	10	15	8
Scarlet Spire	5	12	8	13	11	14	8

**Sum of indices for 5 trees*
1= excellent, 2= moderate, 3= low

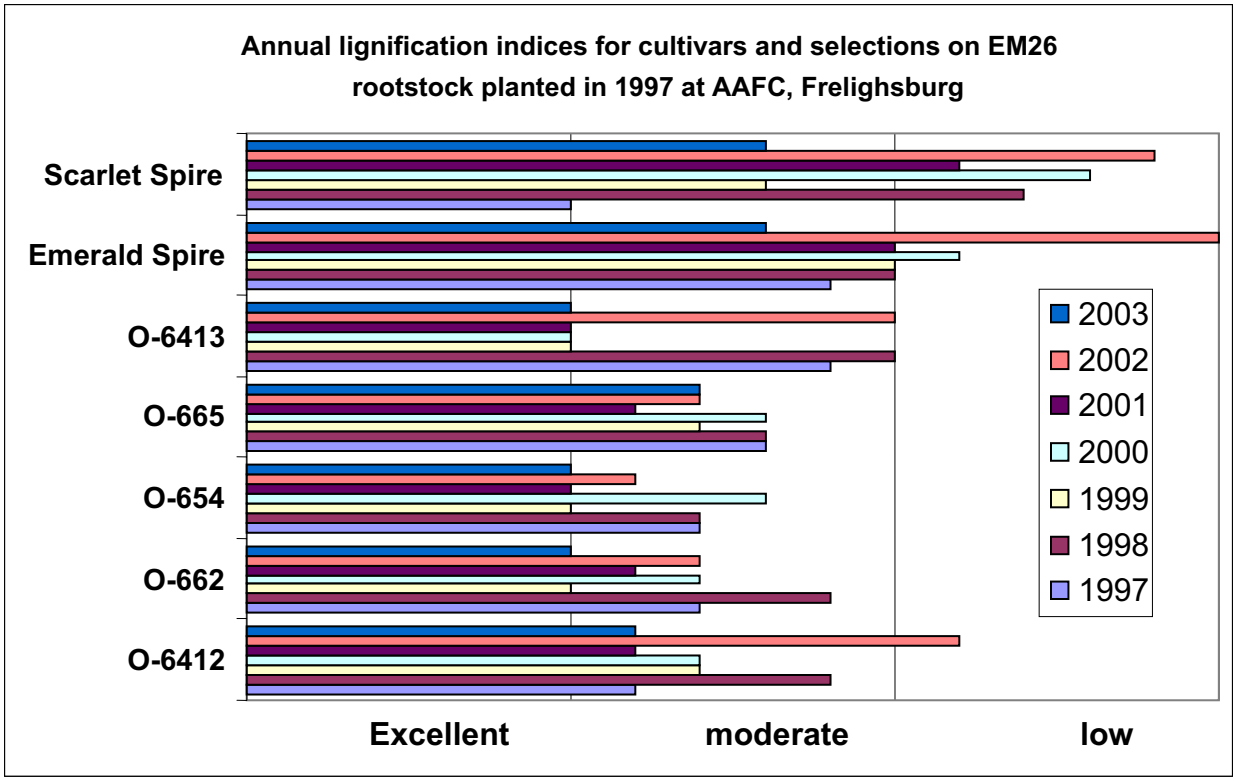


Table 3. Annual yield (Y), cumulative yield (CY), trunk cross-sectional area at 30 cm (TCSA) and productivity, or cumulative yield efficiency (CYE), for 7 cultivars and selections on EM26 rootstock planted in 1997 at AAFC, Frelighsburg

Cultivar	Y 1999 (kg)	Y 2000	Y 2001	Y 2002	Y 2003	CY*	TCSA* (cm^2)	CYE*
Scarlet Spire	1.30	1.34	2.61	1.45	4.17	10.87a	8.55a	1.26a
Emerald Spire	1.10	1.20	2.76	4.38	3.92	13.36a	9.78ab	1.37a
O-665	1.33	3.75	8.92	26.59	5.69	46.28d	28.85e	1.64a
O-662	3.90	0.99	11.18	5.76	14.90	36.74cd	14.96c	2.44b
O-6412	3.86	3.64	6.91	6.61	8.78	29.80bc	12.02bc	2.50b
O-654	4.24	4.68	18.13	14.08	27.10	68.24e	23.48d	2.90bc
O-6413	5.47	7.30	17.31	16.39	21.28	67.75e	15.63c	4.34d

Y = mean yield for 5 trees
CY = sum of Y values, 1999-2003
CYE = CY/TCSA
** Figures followed by the same letter show no significant differences at the 0.05 threshold.*

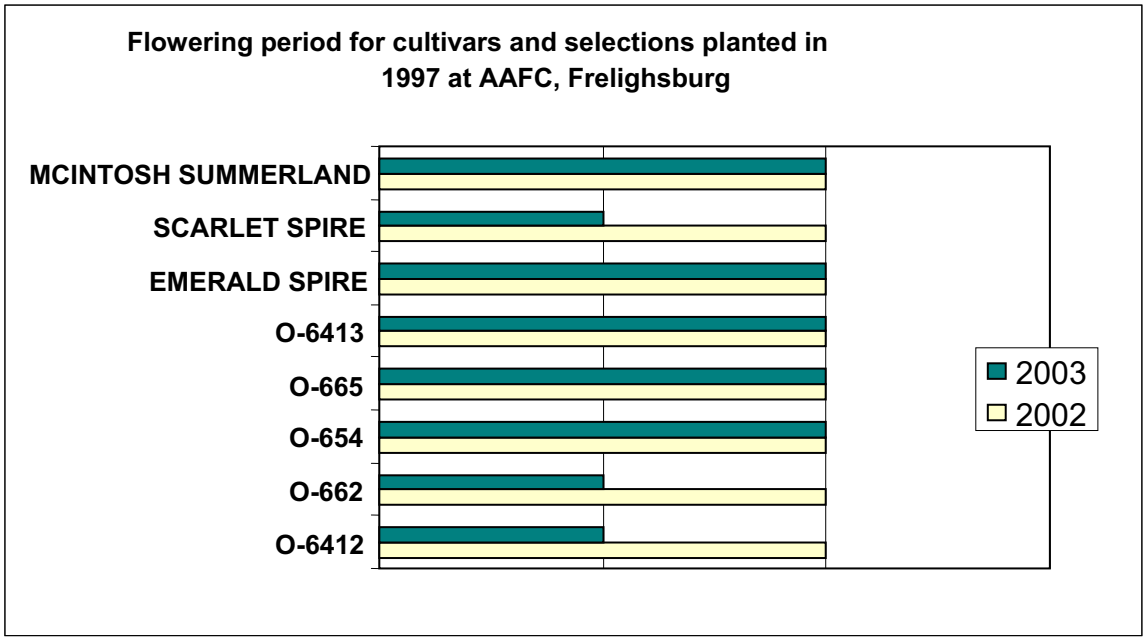
Table 4. Mean fruit weight for 7 cultivars and selections planted in 1997 at AAFC, Frelighsburg

Cultivar	W1999 (g)	W2000 (g)	W2001 (g)	W2002 (g)	W2003 (g)	MW 99-03 (g)*
O-6412	123.93	150.84	118.80	125.30	103.28	124.43a
Scarlet Spire	140.05	150.36	143.36	135.31	155.88	145.83b
O-662	158.49	198.71	125.43	151.59	131.48	152.54b
O-6413	235.35	168.26	124.50	177.38	109.76	163.05bc
Emerald Spire	221.03	217.50	135.30	166.54	203.64	180.80cd
O-654	232.48	241.76	177.46	190.02	165.00	201.34de
O-665	274.15	269.84	194.90	156.18	221.80	218.22e

W = mean weight of 10 fruits per tree for 5 trees
MW = mean value of W, 1999-2003
* *Figures followed by the same letter show no significant differences at the 0.05 threshold.*

Flowering period for cultivars and selections planted in 1997 at AAFC, Frelighsburg

Cultivar	Flowering02	Flowering03
O-6412	10	5
O-662	10	5
O-654	10	10
O-665	10	10
O-6413	10	10
EMERALD SPIRE	10	10
SCARLET SPIRE	10	5
MCINTOSH SUMMERLAND	10	10
before McIntosh Summerland:	*5*	
at the same time as:	*10*	
after:	*15*	



Descriptions of cultivars and selections (see photographs of fruit in Appendix 5).

Stark Summered Treat
Summer apple, harvest late August, fruit red over green.

NJ75
Early season apple, harvest mid-September before McIntosh, fruit yellow, sweet, short storage life, tree highly productive, origin New Jersey, USA.

Mn1403 (Golden Delicious x Red Duchess)
Mid-season apple, harvest at beginning of McIntosh harvest, fruit yellow, sweet, moderate storage life, tree vigorous, susceptible to fireblight, origin University of Minnesota.

Mn1788 (Red Baron x PI123249)
Early season apple, harvest mid-September, attractive red fruit, origin University of Minnesota.

Mn1797 (Sharon x Connell Red)
Late season apple, harvest early October, fruit red, slow to oxidize, origin University of Minnesota.

Zestar! (State Fair x Mn1691)
Summer apple, harvest late August at the same time as Paulared, fruit good, red and crisp, tree as vigorous as McIntosh, origin University of Minnesota.

Regent
Late season apple, harvest mid-October, fruit red-streaked, origin University of Minnesota.

GA001
Mid-season apple, harvest early October, fruit red over green, McIntosh type, origin Rougemont, Quebec of unknown parentage.

Fayette
Summer apple, harvest late August, fruit red-streaked over green, origin verger Claude Goyette, Farnham, Quebec of unknown parentage.

Results and discussion

The winters of 2001 and 2002 were mild, but very cold temperatures of -32°C and -35°C were recorded during the winters of 2003 and 2004 (Appendix 3). Few signs of freezing were observed on the trees included in this trial (Table 5). The cultivars that displayed the most symptoms of freezing were Stark Summered Treat and McIntosh Summerland. The selections and cultivars originating from Minnesota were minimally susceptible to cold: no signs of freezing were observed in the case of Zestar! and MN1788 during the seven years of the project.

Lignification (hardening off) was excellent to moderate for most trees (Table 6). In the case of Stark Summered Treat, Regent, MN1403 and GA001, lignification was poor one year out of eight, and in the case of McIntosh, two years out of eight.

Productivity was moderate to very good (Table 7). The productivity of the control cultivar, McIntosh, was inferior to all the test cultivars except Stark Summered Treat, owing to low annual yields. The highest productivity index was found for NJ75, followed by MN1788, Fayette and Regent. Part of the reason for the high score achieved by MN1788 was the large size of its fruits (Table 8). The fruits produced by GA001, NJ75 and MN1797 were among the smallest.

To sum up, our data on the fruit characteristics and performance of the trees in the orchard during the seven-year trial enable us to classify the various cultivars and selections in terms of their attractiveness for commercial apple production in Quebec.*

Unattractive:

	Weaknesses
Stark Summered Treat	low productivity
Fayette	fruit does not taste good, no sweetness, sour
GA001	fruit does not taste good, red colour inadequate, lack of firmness, small size
Regent	fruit does not taste good, bland, nothing to recommend it
MN1788	fruit does not taste good, bland, no sweetness, poor keeper
NJ75	fruit of mediocre quality, low acidity, lack of firmness
MN1797	tree tends to alternate bear, fruit does not taste good and red colour is inadequate in some years, should be harvested later.

Attractiveness low to moderate:

	Strengths	Weaknesses
MN1403	fruit yellow, sweet, good flavour	tree tends to alternate bear, productivity moderate, storage life moderate
Zestar!	fruit crisp, good flavour, firmness good, tree very cold-resistant	productivity moderate, red colour of fruit inadequate in some years, limited storage life (summer apple)

** It should be noted that this classification is intended for apple growers who sell to the wholesale market.*

Table 5. Annual freezing indices* for cultivars and selections on EM26 rootstock planted in 1998 at AAFC, Frelighsburg

Cultivar	1999	2000	2001	2002	2003	2004
Fayette	5	5	5	5	6	5
GA001	5	6	6	5	8	9
McIntosh Summerland	5	5	7	5	12	7
MN1403	5	6	5	5	9	5
MN1788	5	5	5	5	5	5
MN1797	5	6	7	5	9	6
NJ75	6	5	7	5	7	5
Regent	5	5	5	5	6	6
Stark Summered Treat	5	10	7	5	10	6
Zestar!	5	5	5	5	5	5

**Sum of indices for5 trees*

1 = no sign of freezing, 2 = freezing on terminal bud, 3 = necrosis on trunk and small branches, 4 = death of tree

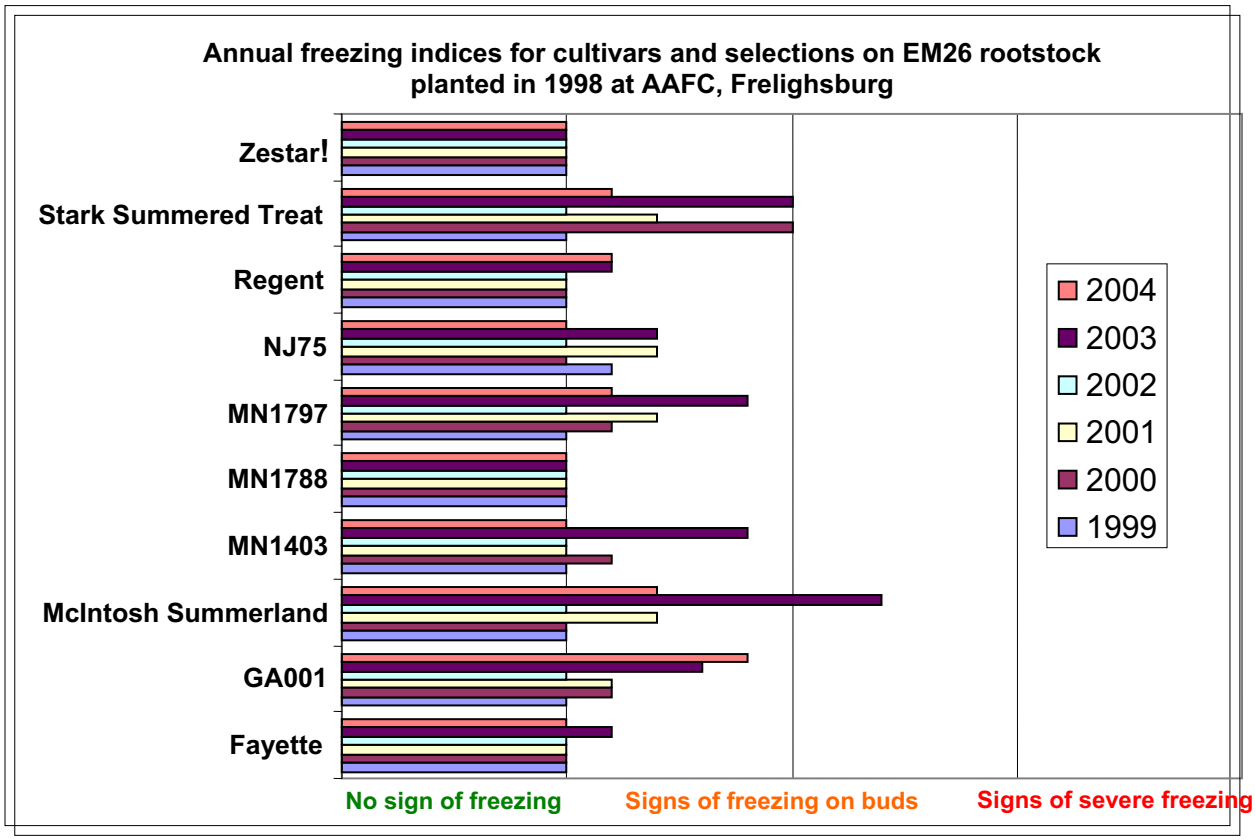


Table 6. Annual lignification indices* for cultivars and selections on EM26 rootstock planted in 1998 at AAFC, Frelighsburg

Cultivar	1998	1999	2000	2001	2002	2003	2004
Fayette	5	5	6	5	6	5	5
GA001	12	9	10	6	10	5	10
McIntosh Summerland	11	7	8	8	11	5	9
MN1403	8	7	10	5	14	9	10
MN1788	10	7	10	5	10	5	6
MN1797	10	7	6	5	8	5	5
NJ75	9	5	7	5	9	5	5
Regent	11	6	10	8	10	5	7
Stark Summered Treat	13	9	10	6	9	6	5
Zestar!	9	7	10	5	5	5	5

**Sum of indices for 5 trees*
1 = excellent, 2 = moderate, 3 = low

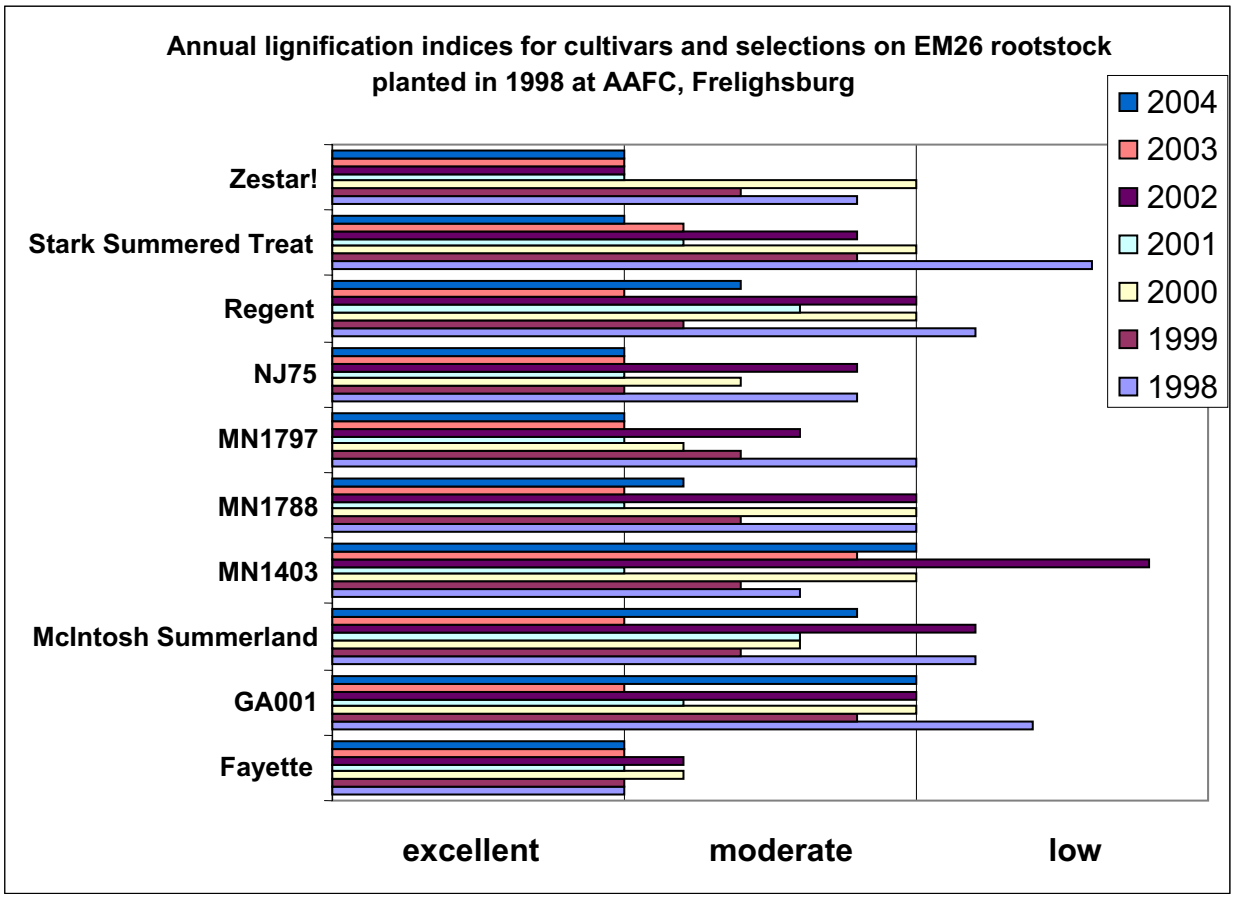


Table 7. Annual yield (Y), cumulative yield (CY), trunk cross-sectional area at 30 cm (TCSA) and productivity (CYE) for 10 cultivars and selections on EM26 rootstock planted in 1998 at AAFC, Frelighsburg

Cultivar	Y 2000 (kg)	Y 2001	Y 2002	Y 2003	Y 2004	CY*	TCSA* (cm^2)	CYE*
Stark Summered Treat	0.87	2.70	0.78	1.63	.	5.97a	23.23bcd	0.27a
McIntosh Summerland	3.46	1.93	13.02	8.32	15.74	36.18b	29.37de	1.23b
MN1403	0.65	15.97	4.73	22.98	20.07	64.40d	32.35e	2.01c
Zestar!	1.10	9.70	5.77	15.92	18.50	50.98bcd	25.18cde	2.12c
GA001	1.12	6.81	10.15	21.01	29.62	62.79cd	31.18e	2.17c
MN1797	1.42	8.91	4.03	16.29	14.21	44.86bc	16.59ab	2.68cd
Regent	1.81	3.48	14.14	13.51	19.86	44.86bc	15.37a	2.86de
Fayette	3.81	8.94	11.73	12.20	19.75	56.43cd	18.97abc	3.00de
MN1788	2.95	9.69	8.80	14.80	16.75	52.99bcd	17.06ab	3.15de
NJ75	4.49	18.96	18.05	22.90	24.89	89.30e	25.95cde	3.42e

Y = mean yield for 5 trees
CY = sum of Y values, 1999-2003
CYE = CY/TCSA
* *Figures followed by the same letter show no significant differences at the 0.05 threshold.*

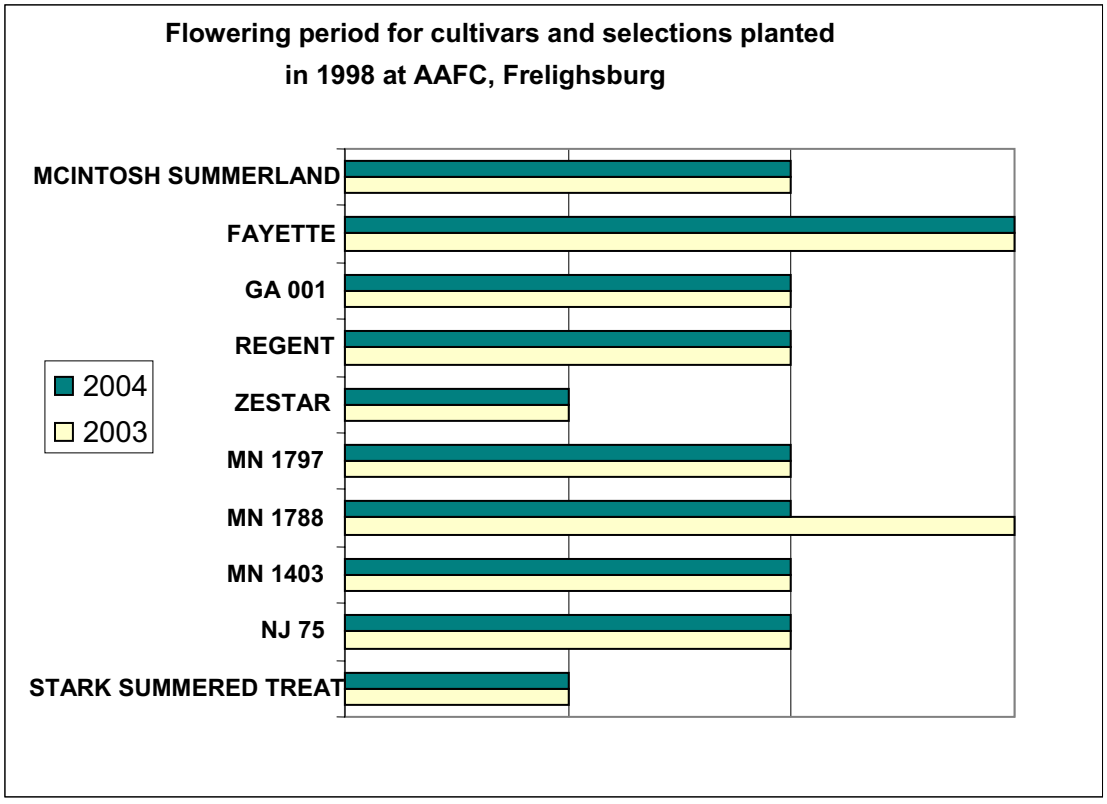
Table 8. Mean fruit weight for 10 cultivars and selections planted in 1998 at AAFC, Frelighsburg

Cultivar	W 2000 (g)	W 2001 (g)	W 2002 (g)	W 2003 (g)	W 2004 (g)	MW 00-04 (g)*
GA 001	157.98	145.42	143.06	148.32	149.70	149.16a
NJ 75	171.26	138.06	133.30	163.76	160.36	153.35ab
MN 1797	161.60	163.24	125.95	170.76	171.56	158.62ab
MN 1403	242.55	152.96	126.97	175.08	177.24	164.48bc
McIntosh Summerland	170.22	187.49	161.70	153.87	176.53	166.95bcd
Zestar!	173.16	215.70	140.66	170.44	178.55	176.18cde
Regent	205.60	193.12	152.26	201.28	146.60	181.67de
Fayette	250.37	182.42	173.32	175.80	170.64	190.51ef
Stark Summered Treat	243.67	171.56	153.02	226.11	.	197.89f
MN 1788	289.66	226.88	192.48	252.80	189.74	226.43g

W = mean weight of 10 fruits per tree for 5 trees
MW = mean value of W, 1999-2003
* *Figures followed by the same letter show no significant differences at the 0.05 threshold.*

Flowering period for cultivars and selections planted at AAFC, Frelighsburg in 1998

Cultivar	Flowering03	Flowering04
STARK SUMMERED TREAT	5	5
NJ 75	10	10
MN 1403	10	10
MN 1788	15	10
MN 1797	10	10
ZESTAR	5	5
REGENT	10	10
GA 001	10	10
FAYETTE	15	15
MCINTOSH SUMMERLAND	10	10
**before McIntosh Summerland:*	*5*	
at the same time as:	*10*	
after:	*15*	



Descriptions of cultivars and selections (see photographs of fruit in Appendix 6)

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8S-27-02 (Splendour x Gala)
Fruit red with yellow flesh, sweet, origin Pacific Agri-Food Research Centre, Summerland, B.C., Canada.

8S-29-18
Fruit red over green with white flesh, origin Pacific Agri-Food Research Centre, Summerland, B.C., Canada.

8S-31-56
Fruit red over yellow with yellow flesh, origin Pacific Agri-Food Research Centre, Summerland, B.C., Canada.

8B-14-56 (Golden Delicious McIntosh 4x)
Fruit red with yellow flesh, origin Pacific Agri-Food Research Centre, Summerland, B.C., Canada.

SPA 343 (Sandow x Schoner aus Nordhausen)
Fruit orange-red over yellow, very sweet, texture firm, origin Pacific Agri-Food Research Centre, Summerland, B.C., Canada.

Chinook (Splendour x Gala)
Fruit red with yellow flesh, origin Pacific Agri-Food Research Centre, Summerland, B.C., Canada.

Silken (Honeygold x Sunrise)
Early season fruit, pale yellow, sweet, low acidity, crisp, origin Pacific Agri-Food Research Centre, Summerland, B.C., Canada.

Aurora Golden Gala (Gala x Splendour)
Fruit yellow, sweet, crisp, excellent storage life, origin Pacific Agri-Food Research Centre, Summerland, B.C., Canada..

Pinova (Duchess of Oldenburg x Cox's Orange Pippin) x Golden Delicious
Very attractive fruit, orange-red colour with yellow flesh, sweet, long storage life, origin Fruit Research Institute in Germany, also marketed under the name "Corail."

Gala Scarlet Mutant of Gala
Fruit streaked orange-red, very colourful, sweet, origin Kentucky, USA.

Jonagold Rubinstar Mutant of Jonagold
Fruit red over yellow, sweet, aromatic, crisp, origin Germany.

NJ114
Summer fruit, rosy-faced yellow, origin New Jersey, USA.

Results and discussion

Signs of freezing were observed on all the trees in this trial following the winter of 2003. That winter was marked by the lowest mean minimum temperature (-28°C) recorded in the entire eight-year trial period (1998-2005). Overall, the cultivars that were least affected by freezing were NJ114 and Silken (Table 9), and those for which the most signs of freezing were observed were Pinova and 8S-31-56.

Lignification indices were moderate to low for most of the trees (Table 10), with NJ114 obtaining the most ratings of "excellent" and Aurora Golden Gala the most "low" lignification ratings.

The yield efficiency for these cultivars and selections was low to moderate, with the exception of Silken, which had a very good productivity index, and Scarlet Gala, which was rated "good" (Table 11). The index for 8B-14-56 reveals very low productivity, owing to its very low annual yields (except in 2004) and its strong vigour. Low annual yields were observed for SPA343 and Pinova every year throughout the trial.

Chinook produced very small to small fruit, while the fruit of 8S-31-56 was quite large, being comparable to the fruit produced by Rubinstar Jonagold (Table 12).

To sum up, our data on the fruit characteristics and performance of the trees in the orchard during the seven-year trial enable us to classify the various cultivars and selections in terms of their attractiveness for commercial apple production in Quebec.*

Unattractive:

	Weaknesses
8B-14-56	Yields too small, harvest too late in the season
8S-29-18	Yields small, harvest too late in the season
8S-31-56	Harvest too late in the season
NJ114	Fruits small and poor quality, harvest too early in the summer
8S-27-02	Harvest too late in the season
Chinook	Harvest too late in the season, fruit small and of variable quality

Attractiveness moderate or specific, or worth pursuing trials at level 2:

	Strengths	Weaknesses
Aurora Golden Gala	fruit yellow, quality good, storage life good	hardened off late, cold tolerance should be retested at level 2, fruit small to medium-sized
Silken	fruit with very good flavour, very productive, for specific markets	fruit all yellow-green (not rosy-faced), storage life moderate, fruit susceptible to scab
Scarlet Gala	fruit colour very attractive,	

	very good Gala flavour	
Pinova	fruit with good flavour and very attractive	harvest late in the season, yield moderate to low, should be retested at level 2
SPA 343	fruit very sweet, spicy, storage life good, for specific markets only	low-yielding, fruit small to medium-sized, harvest late in the season
Rubinstar Jonagold	fruit of very good quality, for direct marketing only	fruit quality variable from year to year, hardened off late

* *It should be noted that this classification is intended for apple growers who sell to the wholesale market.*

Table 9. Annual freezing indices* for cultivars and selections on EM26 rootstock planted in 1999 at AAFC, Frelighsburg

Cultivar	2000	2001	2002	2003	2004	2005
8S-27-02	6	6	7	12	6	10
Chinook	5	6	8	10	8	8
8S-29-18	5	9	6	11	7	9
8S-31-56	5	8	5	10	10	13
Silken	5	6	5	10	5	5
8B-14-56	5	7	5	11	7	11
Aurora Golden Gala	5	5	8	10	5	9
SPA 343	5	5	6	11	10	9
NJ 114	5	5	5	8	5	5
Pinova	5	9	7	10	13	12
Scarlet Gala	5	8	5	7	7	9
Rubinstar Jonagold	5	10	5	7	6	10

**Sum of indices for 5 trees*

1 = no sign of freezing, 2 = freezing on terminal bud, 3 = necrosis on trunk and small branches, 4 = death of tree

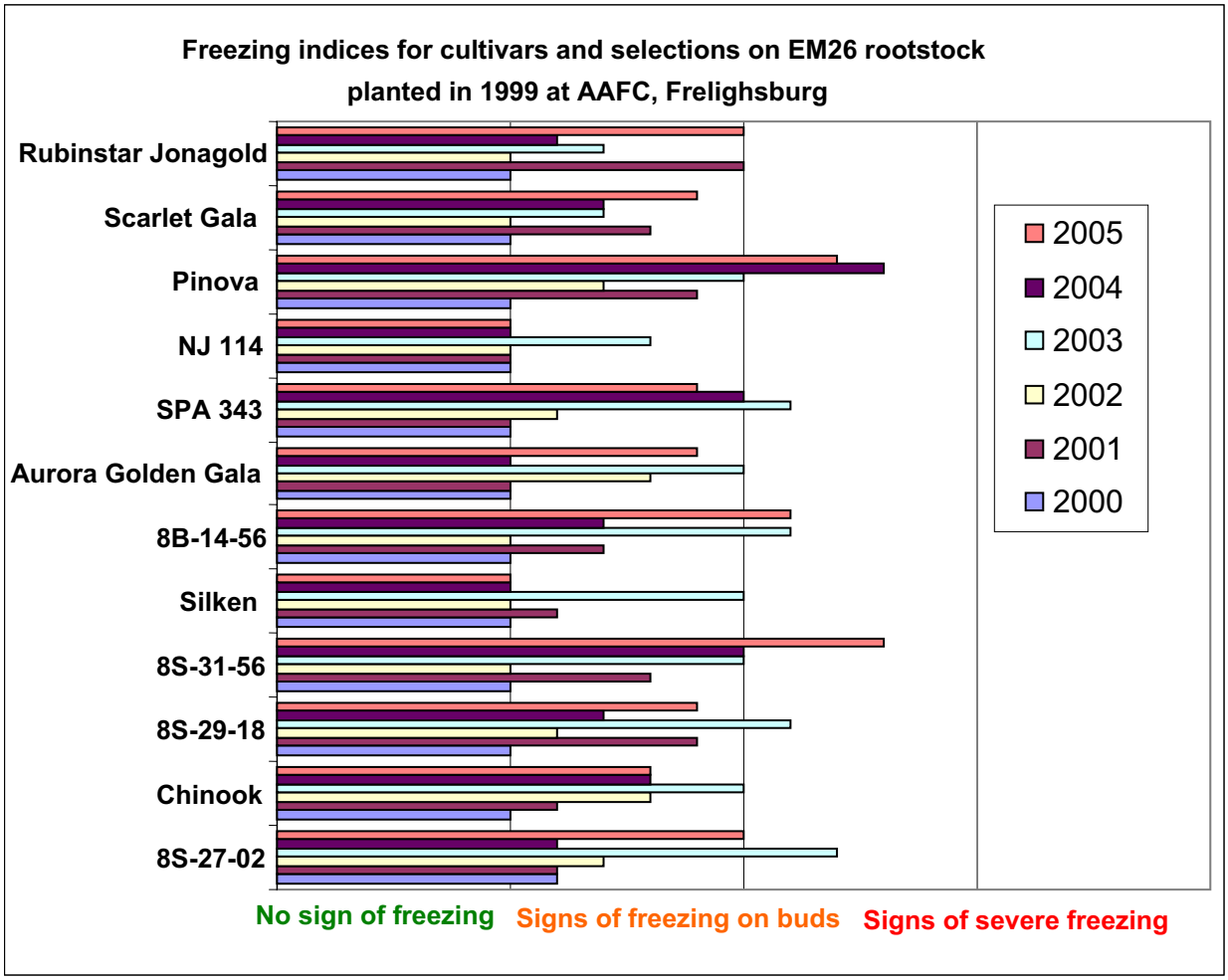


Table 10. Annual lignification indices* for cultivars and selections on EM26 rootstock planted in 1999 at AAFC, Frelighsburg

Cultivar	1999	2000	2001	2002	2003	2004	2005
8S-27-02	10	9	5	10	6	10	5
Chinook	10	10	8	10	6	10	5
8S-29-18	11	12	10	15	9	13	14
8S-31-56	9	11	10	9	10	14	13
Silken	13	9	10	13	8	14	13
8B-14-56	11	11	10	10	9	13	15
Aurora Golden Gala	15	12	7	15	9	14	15
SPA 343	10	9	6	12	5	12	10
NJ 114	9	11	5	5	5	5	5
Pinova	8	11	6	11	8	13	8
Scarlet Gala	9	10	6	10	5	12	11
Rubinstar Jonagold	12	12	6	10	10	11	13

**Sum of indices for 5 trees*
1 = excellent, 2 = moderate, 3 = low

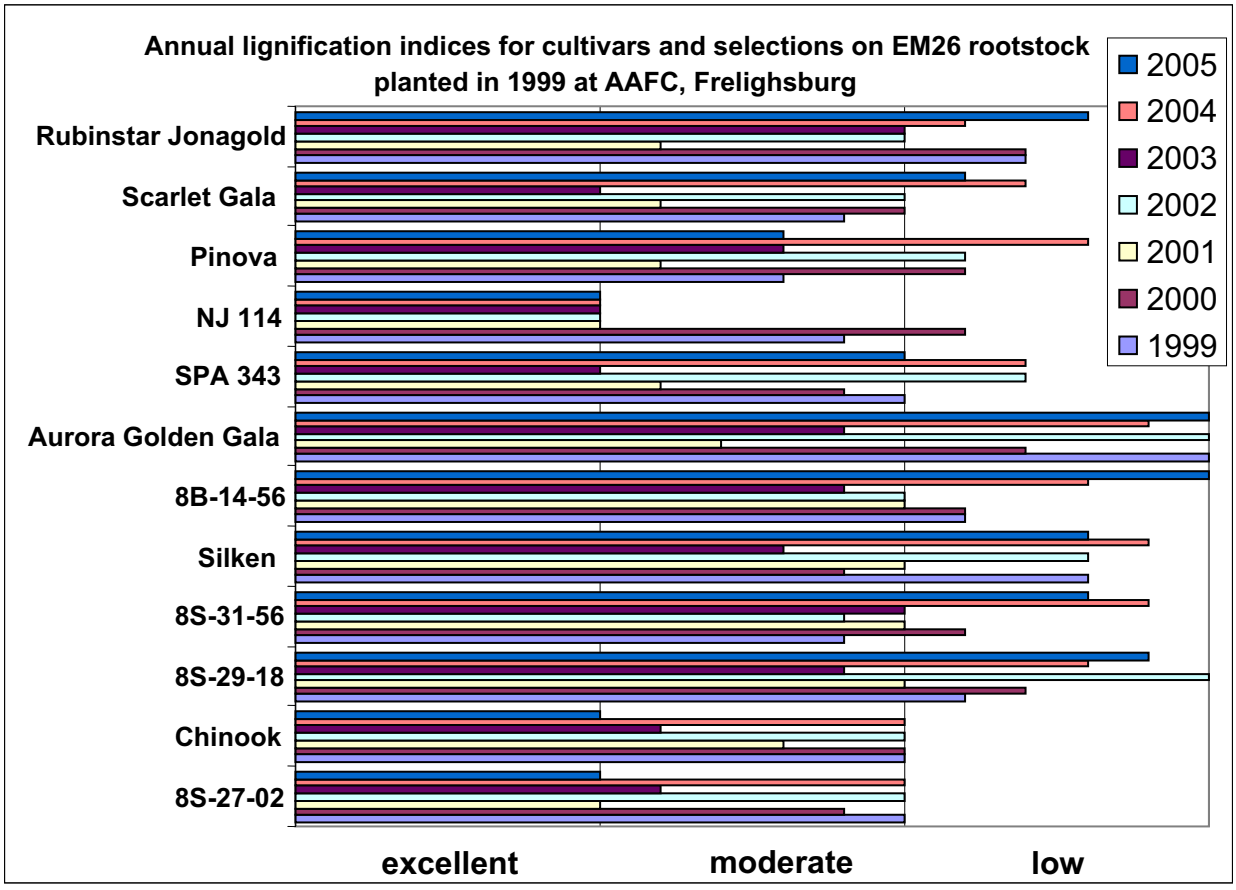


Table 11. Annual yield (Y), cumulative yield (CY), trunk cross-sectional area at 30 cm (TCSA) and productivity (CYE) for 12 cultivars and selections on EM26 rootstock planted in 1999 at AAFC, Frelighsburg

Cultivar	Y 2001 (kg)	Y 2002	Y 2003	Y 2004	Y 2005	CY*	TCSA* (cm^2)	CYE*
8B-14-56	0.52	0.91	5.21	20.95	1.65	29.25a	45.58e	0.64a
8S-29-18	1.05	4.10	8.19	18.22	7.25	38.80ab	30.30cd	1.31b
SPA 343	2.45	1.64	3.61	7.68	13.97	29.57a	21.82ab	1.36b
8S-31-56	0.09	3.73	6.29	19.95	21.84	51.91bc	32.20d	1.62bc
NJ 114	9.07	8.81	8.10	25.61	33.65	85.24e	45.41e	1.89cd
Pinova	4.76	4.27	6.84	11.19	8.24	35.29a	18.37a	2.00de
Chinook	2.17	9.72	8.63	22.13	8.86	51.50bc	23.70ab	2.18de
Aurora Golden Gala	7.11	6.74	13.08	25.32	9.24	61.50cd	28.25bcd	2.19de
Rubinstar Jonagold	10.09	8.35	16.75	18.48	19.59	73.26de	32.06d	2.30e
8S-27-02	9.11	8.57	9.65	26.00	6.76	60.09cd	24.48abc	2.47e
Scarlet Gala	7.81	7.95	10.03	14.64	14.89	55.32c	18.36a	3.01f
Silken	8.23	10.17	15.13	25.11	25.47	84.11e	24.92bc	3.39g

Y = mean yields for 5 trees
CY = sum of Y values, 1999-2003
CYE = CY/TCSA
** Figures followed by the same letter show no significant differences at the 0.05 threshold.*

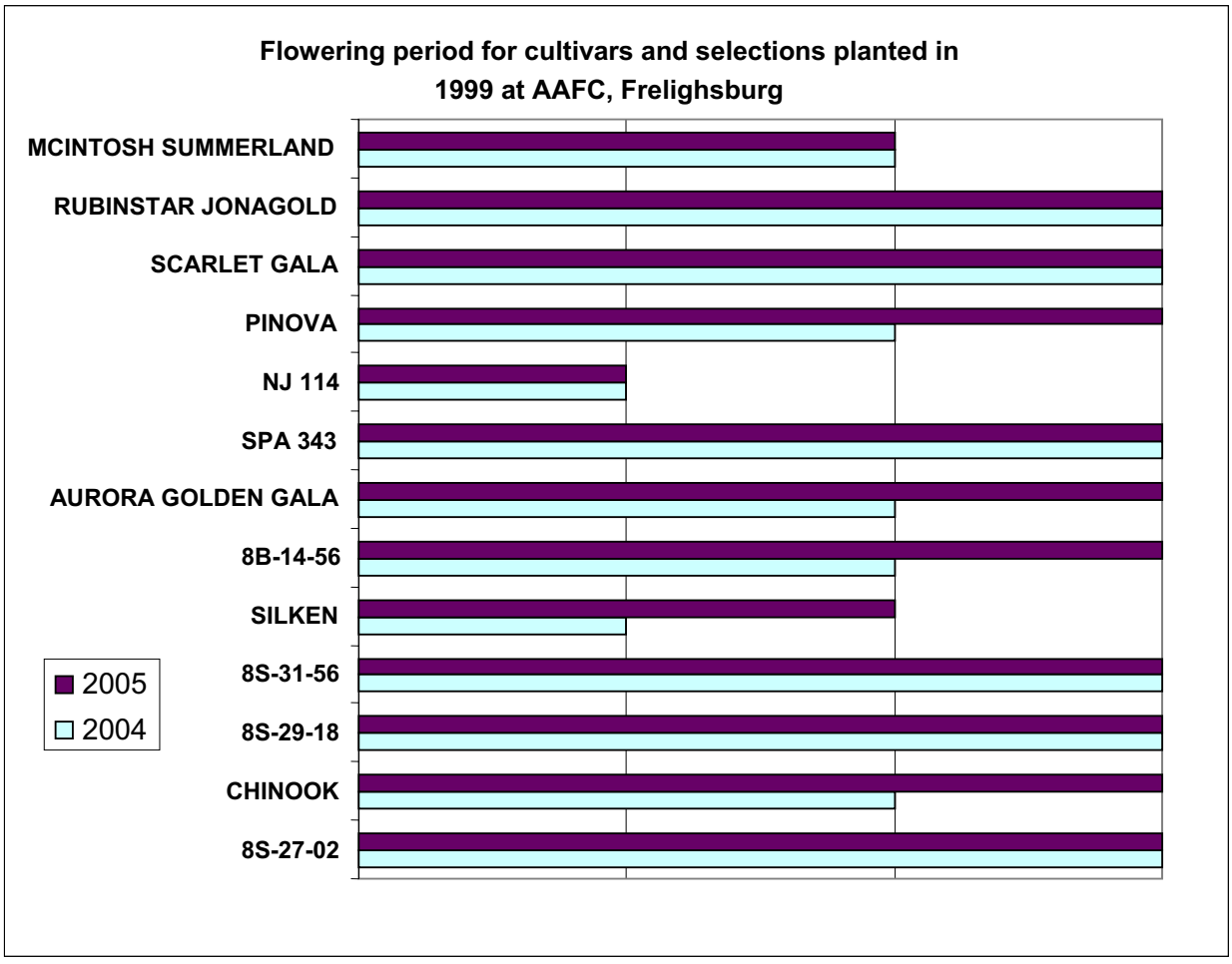
Table 12. Mean fruit weight for 12 cultivars and selections planted in 1999 at AAFC, Frelighsburg

Cultivar	W 2001 (g)	W 2002 (g)	W 2003 (g)	W 2004 (g)	W 2005 (g)	MW 01-05 (g)*
Chinook	84.80	99.50	110.84	131.64	94.84	104.32a
NJ 114	137.28	116.80	88.44	.	106.96	112.37ab
SPA 343	121.00	144.28	103.35	132.15	109.70	122.52b
8S-27-02	114.84	144.62	116.84	128.00	120.16	124.89bc
Scarlet Gala	130.98	129.12	138.08	161.24	132.30	138.34cd
Aurora Golden Gala	148.98	134.10	126.44	148.64	135.12	138.66cd
8S-29-18	129.85	155.92	133.52	153.12	145.64	144.78d
Silken	184.92	149.00	134.84	141.44	126.32	147.30d
Pinova	176.26	182.94	157.48	158.12	157.40	166.44e
8B-14-56	197.60	228.26	170.88	198.36	141.90	186.91f
8S-31-56	237.00	216.21	184.84	191.32	185.80	196.83fg
Rubinstar Jonagold	181.14	243.36	176.76	230.12	181.00	202.48g

W = mean weight of 10 fruits per tree for 5 trees
MW = mean value of W, 1999-2003
** Figures followed by the same letter show no significant differences at the 0.05 threshold.*

Flowering period for cultivars and selections planted in 1999 at AAFC, Frelighsburg

Cultivar	Flowering04	Flowering05
8S-27-02	15	15
CHINOOK	10	15
8S-29-18	15	15
8S-31-56	15	15
SILKEN	5	10
8B-14-56	10	15
AURORA GOLDEN GALA	10	15
SPA 343	15	15
NJ 114	5	5
PINOVA	10	15
SCARLET GALA	15	15
RUBINSTAR JONAGOLD	15	15
MCINTOSH SUMMERLAND	10	10
before McIntosh Summerland:	*5*	
at the same time as:	*10*	
after:	*15*	



Evaluation for susceptibility to the main summer diseases

The 1999 planting was kept until late in the autumn of 2006, this enabled us to observe the susceptibility of the six cultivars and selections listed below to the main summer apple diseases:
Scarlet Gala (T95)
SPA 343 (T92)
Aurora Golden Gala (T90)
Pinova (T94)
Silken (T88)
McIntosh Summerland (T97)

One hundred fruits were harvested at random (twenty fruits per replication) on September 28, 2006, from the five trees of each of the cultivars and selections under observation. Each one of the 100 fruits was evaluated the same day and given a rating of 1 if symptoms were present and a rating of 0 if symptoms were not present.

A spraying program designed to prevent primary apple scab infection was applied in that plot during May and June. The program consisted of a series of preventive or protective fungicide treatments with contact products, interspersed on occasion with curative or eradicant treatments with systemic fungicides. No fungicides were sprayed after June 20, 2006.

The spring of 2006 was very rainy, especially during the flowering period of the apple trees. The summer of that year was humid, fairly hot, and cloudy. That is to say, conditions were ideal for the development of the main summer diseases. It is important to note that the site of the experimental plot was protected from westerly and southerly winds, and consequently air circulation there was rather poor.

The sampled fruits were examined for symptoms of the diseases and disorders listed below:
Apple scab
Powdery mildew
Russeting
Blossom-end rot
Sooty blotch
Fly speck
Superficial red stains (cause unidentified)

Results and discussion

All the cultivars and selections included in the evaluation were affected by sooty blotch. Aurora Golden Gala and Pinova were the most seriously affected, with 91% of their fruits displaying symptoms, followed by SPA 343 (77%), Silken (73%) and Scarlet Gala (71%). The cultivar that was least seriously affected was Summerland McIntosh, with 54% of its fruits showing symptoms.

Fly speck, which flourishes under the same conditions as sooty blotch, was also prevalent. The cultivars that were found to be most susceptible to sooty blotch were also those that were most susceptible to fly speck: Aurora Golden Gala (86%), Pinova (78%) and Silken (78%). These were followed by Scarlet Gala (53%), Summerland McIntosh (49%) and SPA 343 (47%).

The cultivar that proved to be most susceptible to scab was Summerland McIntosh, with the very high incidence of 96% of its fruits affected, followed by Silken with 18 % scabby fruit, Pinova with 2% and Scarlet Gala with 1%. No SPA 343 or Aurora Golden Gala apples displayed any symptoms of scab.

Blossom-end rot affected 8% of the Scarlet Gala fruits, 2% of those of the Aurora Golden Gala and 1% of the Pinova. No SPA 343, Silken or Summerland McIntosh apples displayed any symptoms of blossom-end rot.

Many fruits were found to be russeted. It is highly likely that the poor air circulation at the site was a contributing factor in the development of this defect. The fruits of SPA 343 were very heavily affected, with an incidence of 97%, followed by those of Aurora Golden Gala (29%), Scarlet Gala (6%), Silken and McIntosh (4%) and Pinova (1%).

A substantial proportion (42%) of the Aurora Golden Gala apples were covered with minuscule concentric red stains. These stains were superficial and did not affect the flesh of the apples. We were unable to identify them. The same symptom was observed in the case of 9% of the Silken apples and 1% of the Pinova apples.

None of the fruits showed any signs of powdery mildew.

Table 13. Presence of summer disease symptoms on 100 fruits from 6 cultivars and selections planted in 1999 at AAFC, Frelighsburg *(observations made in September 2006).*

Cultivar	# fruits	Sooty blotch	Scab	Fly speck	Red stains	Powdery mildew	Russeting	Blossom-end rot
Gala Scarlet T95	100	71b	1c	53b	0c	0	6c	8a
SPA 343 T92	100	77b	0c	47b	0c	0	97a	0c
Pinova T94	100	91a	2c	78a	1c	0	1c	1c
Aurora Golden Gala T90	100	91a	0c	86a	42a	0	29 b	2b
Silken T88	100	73b	18b	78a	9b	0	4c	0c
McI Summerland T97	100	54c	96a	49b	0c	0	4c	0c

** 0 = absence, 1 = presence*

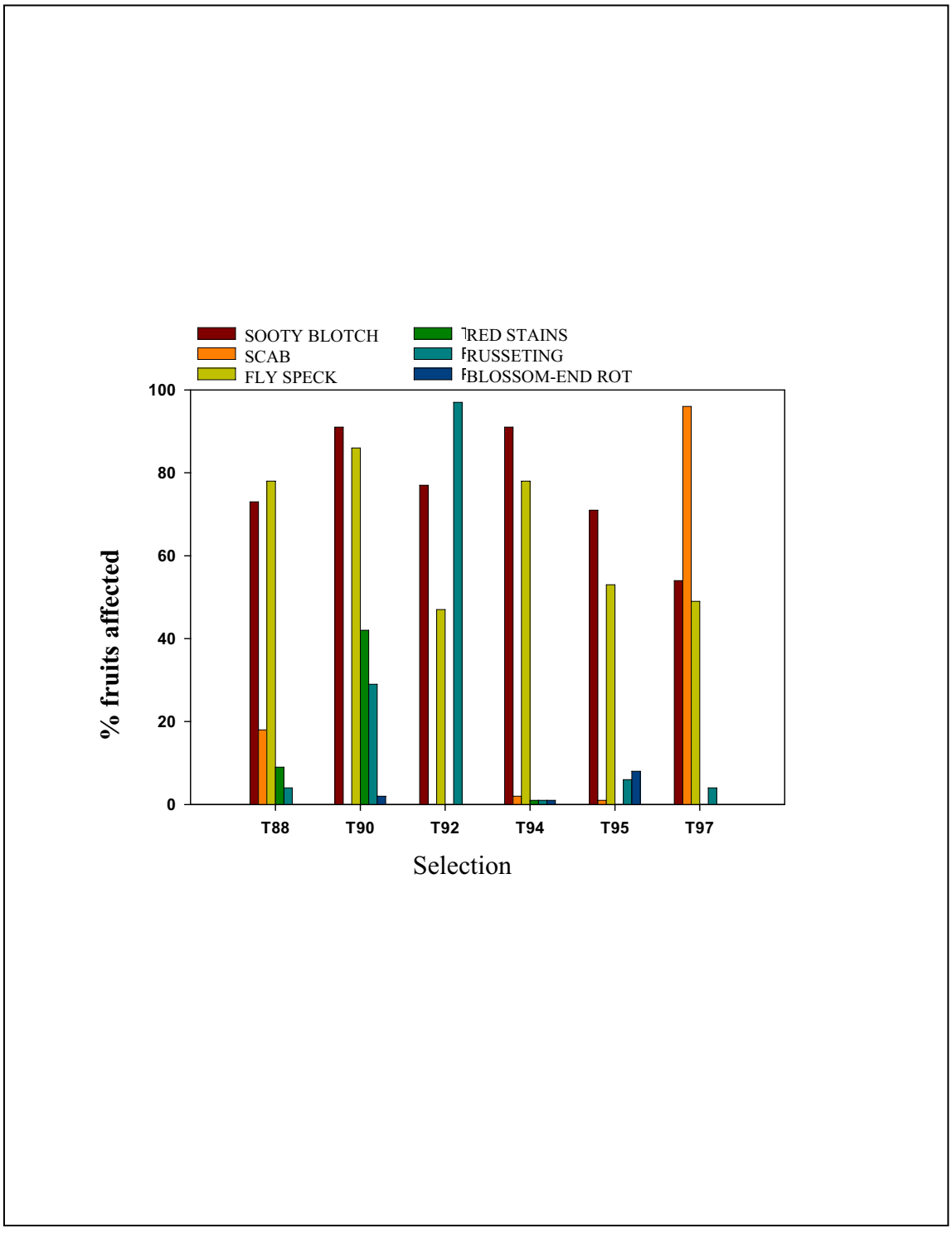
** Figures followed by the same letter show no significant differences at the 0.05 threshold.*

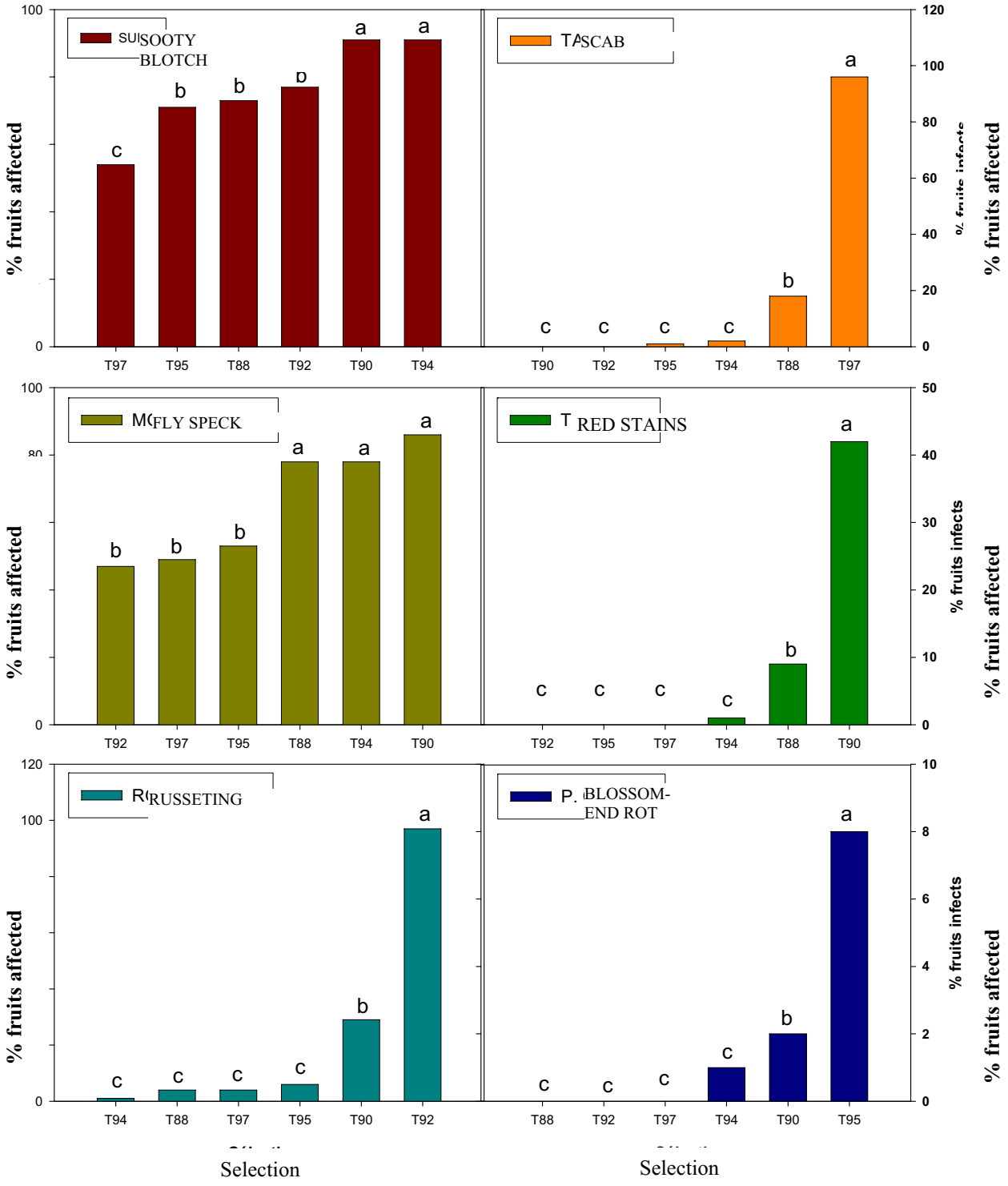
Tables 14 and 15. Presence of summer disease symptoms on 100 fruits from 6 cultivars and selections planted in 1999 at AAFC, Frelighsburg. *(Frelighsburg, September 2006)*

0 = symptoms not present

1 = symptoms present

Analysis and charts by Odile Carisse, Ph.D., Horticulture Research and Development Centre, Saint-Jean-sur-Richelieu, AAFC.




SOOTY BLOTCH
SCAB
FLY SPECK
RED STAINS
RUSSETING
BLOSSOM-END ROT
% fruits affected
% fruits infects
Selection
T97 T95 T88 T92 T90 T94
T90 T92 T95 T94 T88 T97
T92 T97 T95 T88 T94 T90
T92 T95 T97 T94 T88 T90
T94 T88 T97 T95 T90 T92
T88 T92 T97 T94 T90 T95

Rootstock trial, 1996-2005

Description of rootstocks:

Budakovsky 491, Vineland 605-4, Ottawa 8, Polish 18 and EMLA 26.
Owing to propagation problems, we were unable to conduct trials with both McIntosh and Spartan for all the rootstocks. Two rootstocks, B491 and O8, were evaluated with Spartan only, V605-4 was evaluated with McIntosh Summerland only, and P18 was evaluated with both cultivars (McIntosh on O8 rootstock was evaluated during the period 1998-2005). EM26 was used as the control rootstock for both cultivars. Descriptions of the rootstocks evaluated are given below.

B491: Budakovsky 57-491, a very dwarf rootstock originated in Russia, readily propagated by coppicing, susceptible to fire blight and woolly apple aphid, cold-resistant.

V605-4: Vineland 4, a dwarf rootstock originated at Vineland, Ontario, Canada, Kerr (Dolgo x Haralson) crab apple seedling.

O8: Ottawa 8, a semi-dwarf rootstock originated at Ottawa, Canada, Malus baccata gracilis x EM7 cross, susceptible to fire blight and woolly apple aphid.

P18: Polish 18, a vigorous rootstock originated in Poland, Malling 4 x Antonovka cross, cold-resistant, phytophtora-resistant, slightly susceptible to fire blight, susceptible to woolly aphid.

Vigour of McIntosh Summerland and Spartan on four rootstocks after having been grown for nine years at AAFC Frelighsburg, Qc, Canada

McIntosh/rootstock	TCSA (cm^2)	/TCSAEM26	Spartan/rootstock	TCSA (cm^2)	/TCSAEM26
V605-4	44.37a	0.96	Bud 491	10.05a	0.33
EM26	45.76a	1.00	EM26	30.05a	1.00
P18	168.64b	3.68	O8	64.89b	2.16
			P18	136.64c	4.55

Figures followed by the same letter show no significant differences at the 0.05 threshold.

Cold resistance and lignification

McIntosh proved to be less cold-sensitive on the V605-4 and P18 rootstocks than on EM26 (Table 16). McIntosh on V605-4 rootstock sustained the least freezing damage. This rootstock sustained no freezing damage, except in 2003 and 2005, when temperatures fell below -30°C (Appendix 2).

Spartan proved to be less cold-sensitive with the B491 and P18 rootstocks than with O8 and EM26 (Table 17). Our results from our trial with McIntosh during the period 1998-2005 also indicate that the O8 rootstock is comparable to EM26 in terms of cold sensitivity (Table 37).

McIntosh on V605-4 rootstock hardened off better than McIntosh on EM26 or P18 rootstock seven years out of ten (Table 18). McIntosh on P18 rootstock was comparable with the same cultivar on EM26; however, its lignification index improved after seven years under orchard conditions, when the trees reached bearing age and the vigour reached a balance.

In the case of Spartan, better lignification indices were observed on B491 rootstock than on EM26, P18 or O8 (Table 19). Lignification indices for this cultivar on O8 and P18 rootstock indicate moderate to low lignification during the first seven years under orchard conditions, with improvement thereafter once the trees had attained a balance between fruit and vigour.

Table 16. Annual freezing indices* for McIntosh Summerland on three different rootstocks planted in 1996 at AAFC, Frelighsburg, Qc, Canada

PG	1997	1998	1999	2000	2001	2002	2003	2004	2005
EM26	6	5	5	11	5	6	9	5	5
P18	8	5	5	5	5	8	5	5	6
V605-4	5	5	5	5	5	5	6	5	6

**Sum of indices for 5 trees*

1 = no sign of freezing, 2 = freezing on terminal bud, 3 = necrosis on trunk and small branches, 4 = death of tree

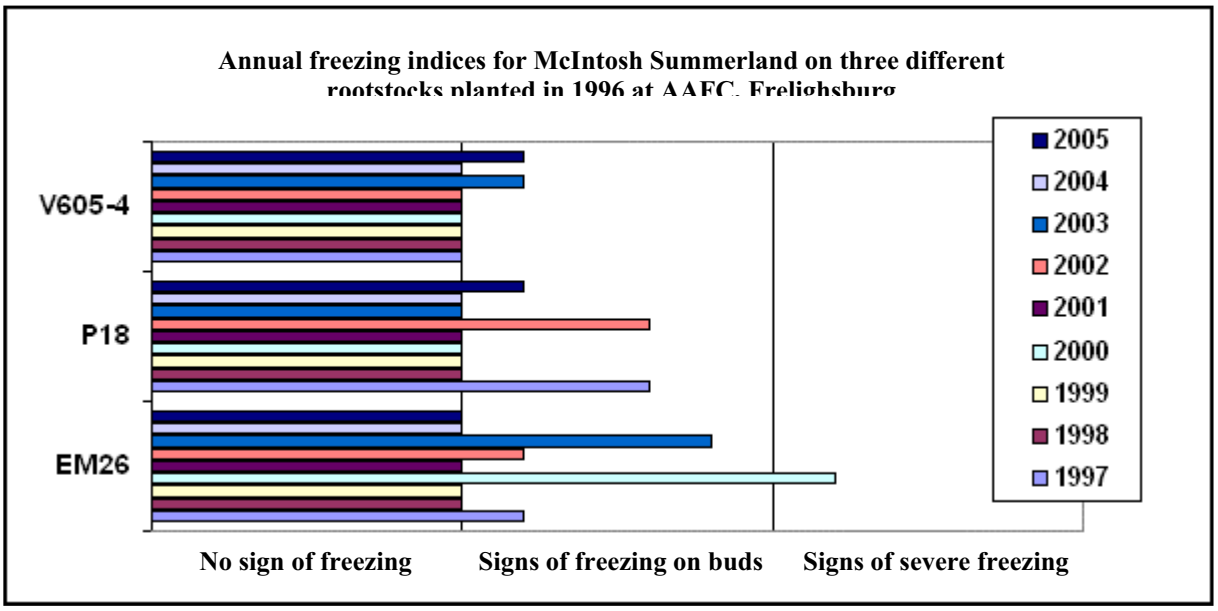


Table 17. Annual freezing indices* for the cultivar Spartan on four different rootstocks planted in 1996 at AAFC, Frelighsburg, Qc, Canada

PG	1997	1998	1999	2000	2001	2002	2003	2004	2005
Bud 491	5	5	5	10	6	10	9	8	8
EM26	5	5	5	10	7	7	11	8	6
O8	8	5	5	11	6	5	13	6	9
P18	9	5	5	6	5	5	10	5	7

**Sum of indices for 5 trees*

1 = no sign of freezing, 2 = freezing on terminal bud, 3 = necrosis on trunk and small branches, 4 = death of tree

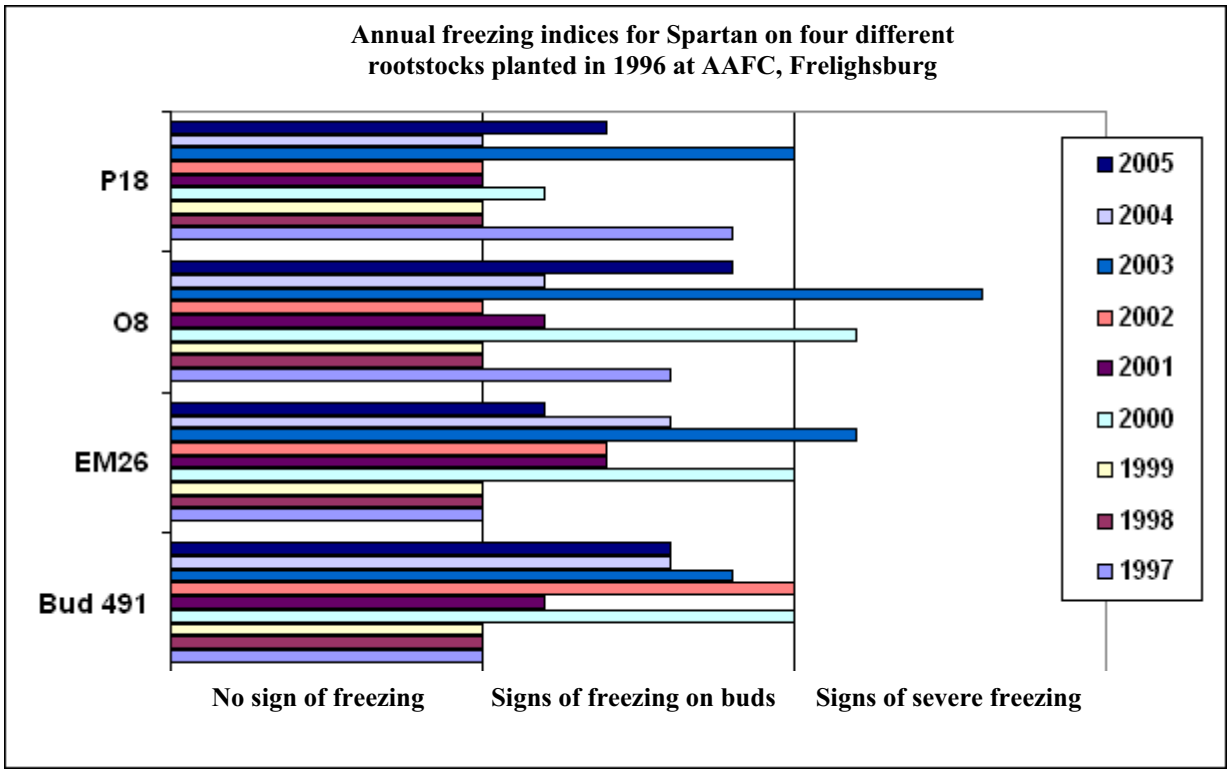


Table 18. Annual lignification indices* for the cultivar McIntosh Summerland on three different rootstocks planted in 1996 at AAFC, Frelighsburg, Qc, Canada

Rootstock	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
V605-4	8	8	9	5	7	5	5	5	5	9
P18	8	12	10	5	12	6	5	7	8	7
EM26	7	11	7	8	7	6	11	7	8	11

**Sum of indices for 5 trees*

1 = excellent, 2 = moderate, 3 = low

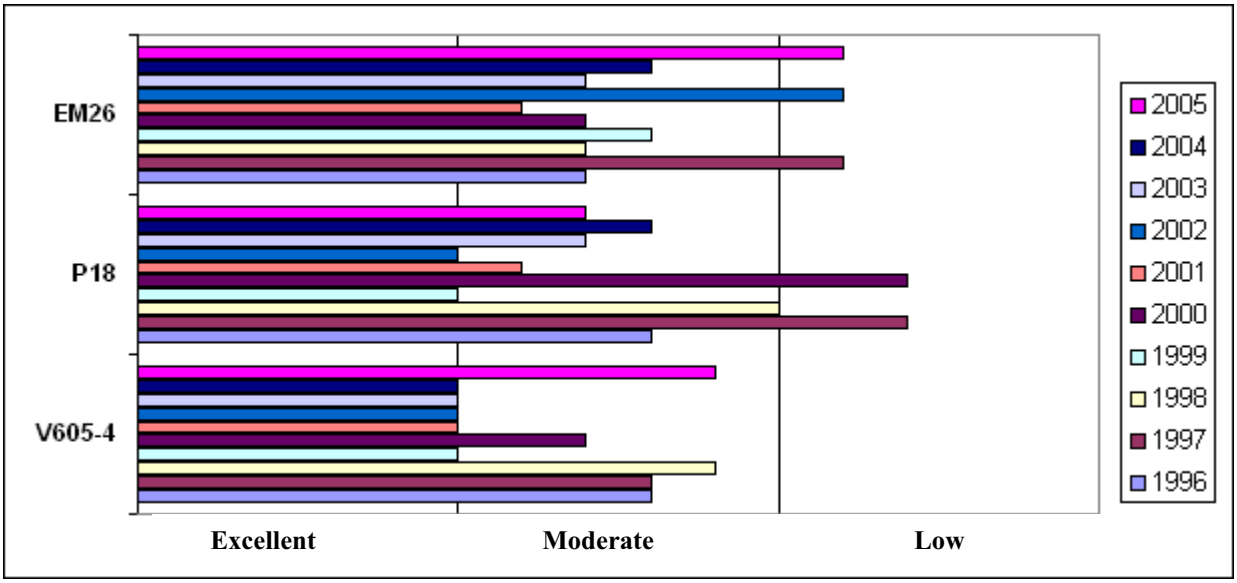
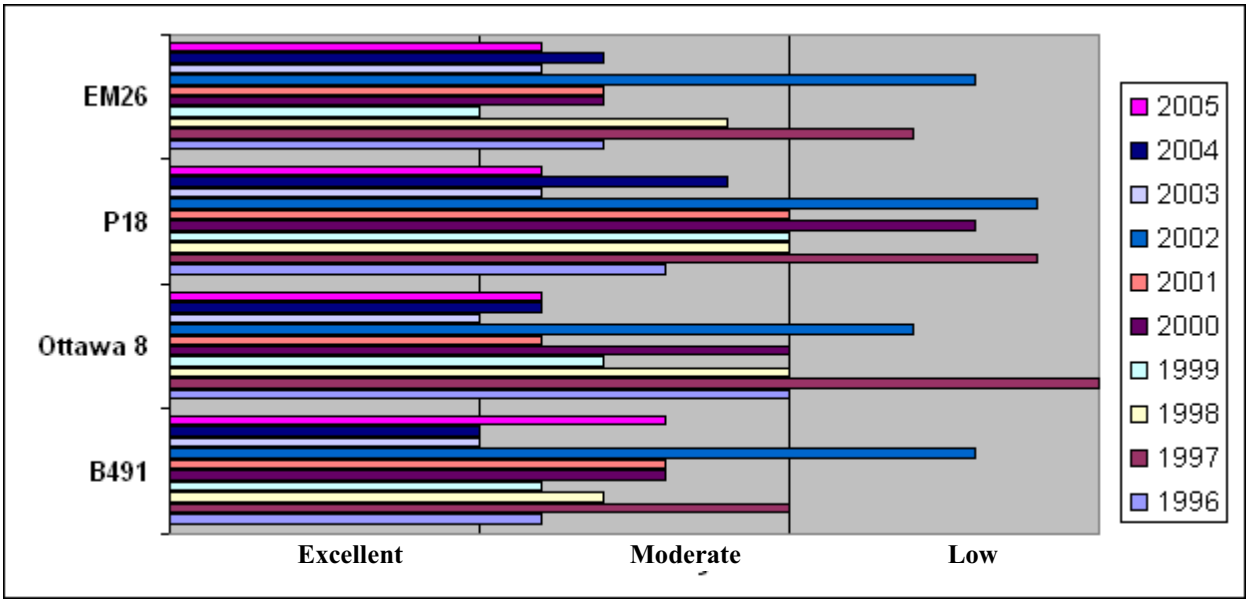


Table 19. Annual lignification indices* for the cultivar Spartan on four different rootstocks planted in 1996 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
B491	6	10	7	6	8	8	13	5	5	8
Ottawa 8	10	15	10	7	10	6	12	5	6	6
P18	8	14	10	10	13	10	14	6	9	6
EM26	7	12	9	5	7	7	13	6	7	6

**Sum of indices for 5 trees*

1 = excellent, 2 = moderate, 3 = low



Suckering and burrknots

When grafted with McIntosh, the P18 rootstock was less prone to suckering than the V605-4 or EM26. However, this advantage was lost after eight years under orchard conditions, when it began to produce moderate quantities of suckers every year (Table 20). The V605-4 rootstock was less prone to suckering than the EM26.

When grafted with Spartan, the P18 rootstock produced no suckers for five years. Beginning in the sixth year, suckering increased from year to year (Table 21). The B491 rootstock was less prone to suckering than the EM26 or the P18. The EM26 and O8 rootstocks suckered abundantly beginning in the sixth year under orchard conditions.

With McIntosh, the P18 and V605-4 rootstocks produced few burrknots (Table 22). The EM26 rootstock, however, was moderately to highly prone to burrknots.

When grafted with Spartan, the P18 rootstock produced few burrknots, fewer than the B491, O8 or EM26 rootstocks (Table 23). The B491 and O8 rootstocks were moderately prone to burrknots, producing fewer of them than the EM26.

Table 20.

Annual suckering indices* for the cultivar McIntosh Summerland on three different rootstocks planted in 1996 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
V605-4	5	5	6	8	5	8	5	9	10	9
P18	5	5	5	5	5	5	5	7	9	6
EM26	5	6	9	12	10	9	5	12	13	12

Suckering index: *1. None*
2. Moderate
3. Severe

** Sum of indices from 5 replications.*

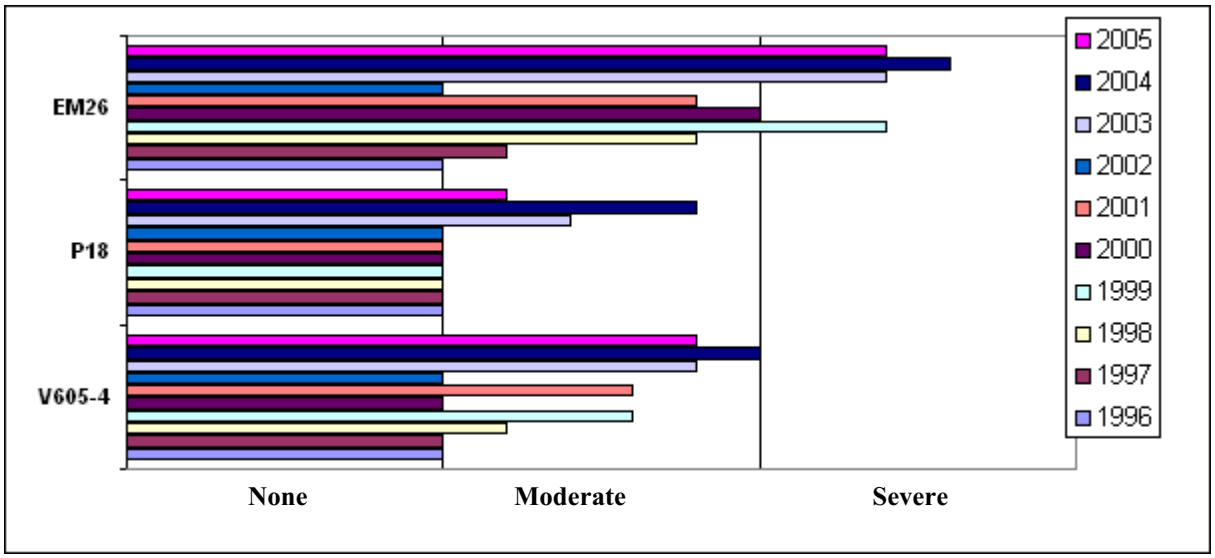


Table 21.

Annual suckering indices* for the cultivar Spartan on four different rootstocks planted in 1996 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
B491	5	6	6	6	5	8	8	8	8	9
Ottawa 8	6	7	8	15	6	15	15	15	15	15
P18	5	5	5	5	5	6	6	9	11	13
EM26	5	7	11	14	9	13	14	15	15	15

Suckering index: *1. None*
2. Moderate
3. Severe

** Sum of indices from 5 replications.*

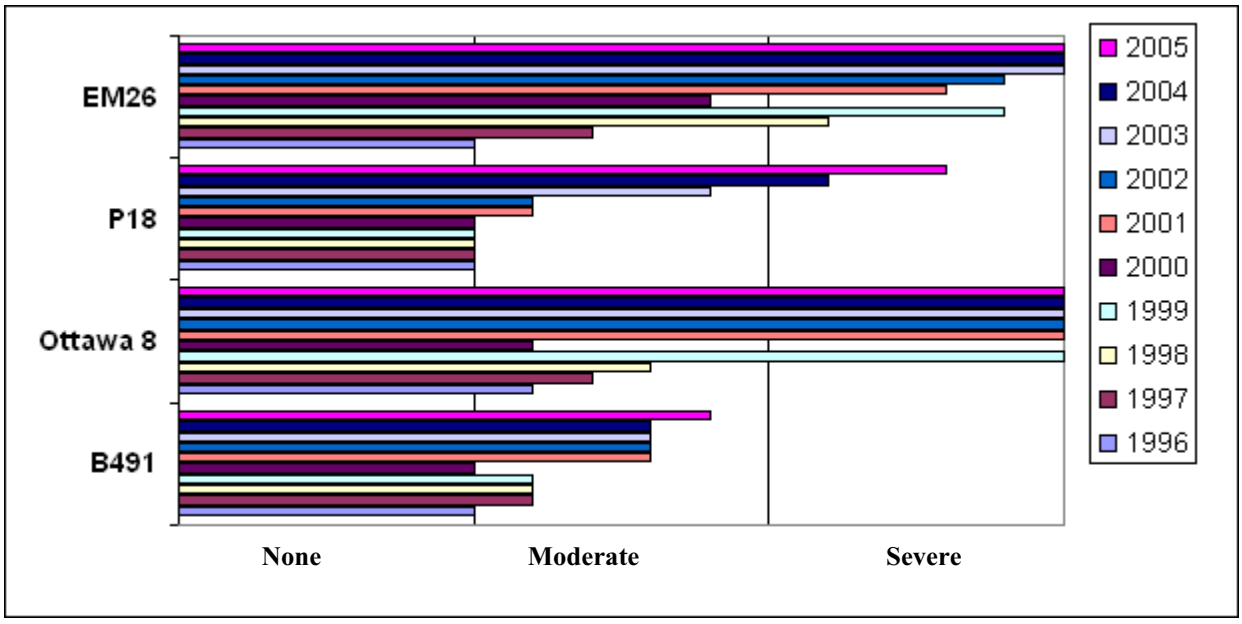


Table 22.

Annual burrknot production indices* for the cultivar McIntosh Summerland on three different rootstocks planted in 1996 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
V605-4	5	6	6	9	8	6	5	5	5	8
P18	5	5	5	9	5	6	5	5	5	6
EM26	9	13	12	14	12	11	5	9	10	11

Burrknot production index: *1. Low*
2. Moderate
3. Severe

** Sum of indices for 5 replications.*

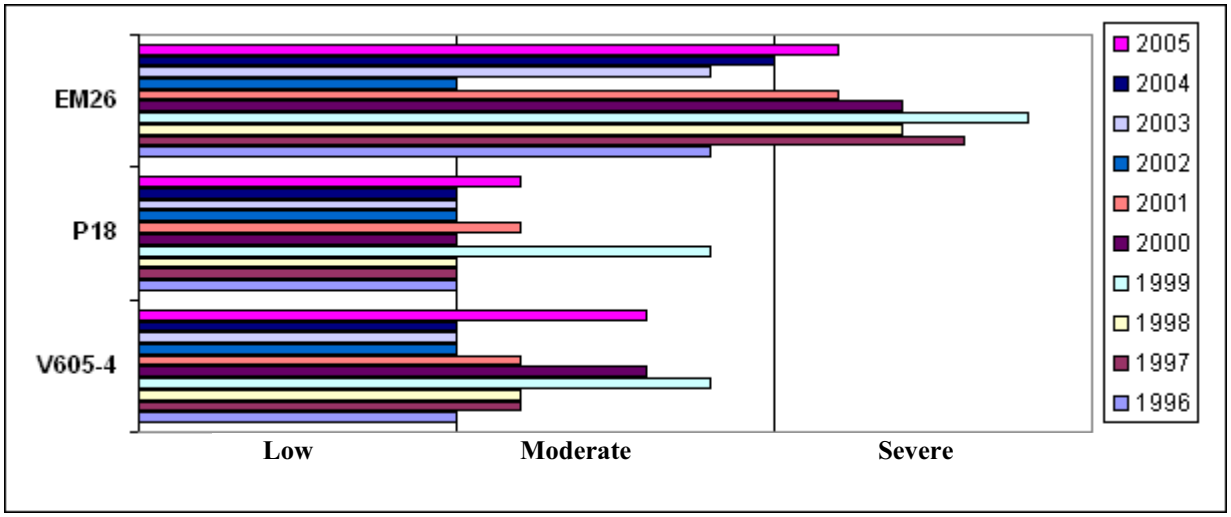
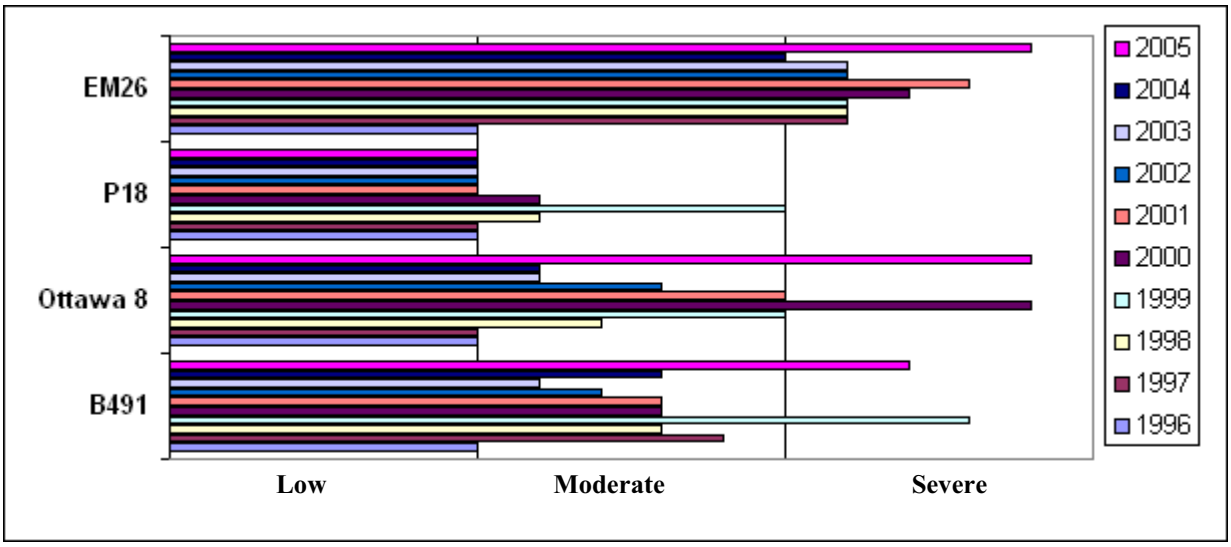


Table 23.
Annual burrknot production indices* for the cultivar Spartan on four different rootstocks planted in 1996 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
B491	5	9	8	13	8	8	7	6	8	12
Ottawa 8	5	5	7	10	14	10	8	6	6	14
P18	5	5	6	10	6	5	5	5	5	5
EM26	5	11	11	11	12	13	11	11	10	14

Burrknot production index: *1. Low*
2. Moderate
3. Severe

** Sum of indices for 5 replications.*



Annual yield and productivity

Two vigour categories were represented in this trial with the cultivar McIntosh: vigorous with the P18 rootstock and dwarf with the EM26 and V605-4 rootstocks (Table 24).

In the dwarf category, no significant difference between the V605-4 and the EM26 rootstocks was observed in terms of trunk cross-sectional area (TCSA), cumulative yield (CY), and productivity, as measured by cumulative yield efficiency (CYE).

CYE was lower with McIntosh on the P18 rootstock than with the same cultivar on EM26 or V605-4, while CY was higher. This vigorous rootstock requires seven to eight years of growth before it attains its full production capacity. That is the explanation for its low CYE during the first 10 years of the trial.

The trial with the cultivar Spartan involved rootstocks of three vigour categories: vigorous with P18, semi-dwarf with O8 and dwarf with EM26 and B491 (Table 25).
In the dwarf category, CYE was greater with the B491 rootstock than with the EM26. This is attributable to the fact that B491 is more dwarfing than EM26, although no significant difference between the two was observed in terms of their respective vigour indices (TCSA).

The semi-dwarf rootstock O8 was outperformed by EM26 in terms of CYE, but no significant difference was observed between O8 and P18. The cultivar Spartan on O8 produced full yields beginning in the seventh year under orchard conditions. Cumulative yield (CY) and vigour index (TCSA) for this rootstock were inferior to those of P18 but superior to those of EM26.

The vigorous rootstock P18 displayed the same characteristics with Spartan as with McIntosh: inferior to EM26 in terms of productivity (CYE), but outperforming it in terms of vigour index (TCSA) and cumulative yield. Spartan on the P18 rootstock appeared to reach full production in approximately its eighth year under orchard conditions.

Table 24.
Annual yield (Y), cumulative yield (CY), vigour (TCSA) and productivity (CYE) for the cultivar McIntosh Summerland on three different rootstocks planted in 1996 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	Y 98 (kg)	Y 99	Y 2000	Y 2001	Y 2002	Y 2003	Y 2004	Y 2005	CY	TCSA (cm^2)	CYE
P18	0.36	2.77	9.44	11.66	7.30	54.92	107.88	117.49	311.83b	168.64b	1.96b
EM26	5.84	6.10	10.10	12.32	6.54	32.40	40.12	45.87	159.30a	45.76a	3.58a
V605-4	3.24	7.77	15.92	17.83	18.46	34.32	40.86	37.37	175.78a	44.37a	3.95a

Y = mean yields for 5 trees
CY = sum of Y values, 1998-2005
TCSA = trunk cross-sectional area at a height of 30 cm
CYE = CY/TCSA
* *Figures followed by the same letter show no significant differences at the 0.05 threshold.*

Table 25.
Annual yield (Y), cumulative yield (CY), vigour (TCSA) and productivity (CYE) for the cultivar Spartan on four different rootstocks planted in 1996 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	Y 98 (kg)	Y 99	Y 2000	Y 2001	Y 2002	Y 2003	Y 2004	Y 2005	CY	TCSA (cm^2)	CYE
P18	2.14	5.15	17.17	11.77	23.16	66.66	85.79	92.35	304.17d	136.64c	2.25a
O8	4.28	5.66	22.30	7.50	27.19	49.99	38.87	47.88	203.68c	64.89b	3.21a
EM26	4.38	9.81	11.18	9.34	13.90	23.98	28.33	36.23	137.15b	30.05a	4.60b
Bud 491	2.16	4.36	4.60	4.19	7.44	13.57	15.43	12.61	64.36a	10.05a	6.41c

Y = mean yields for 5 trees
CY = sum of Y values, 1998-2005
TCSA = trunk cross-sectional area at a height of 30 cm
CYE = CY/TCSA
* *Figures followed by the same letter show no significant differences at the 0.05 threshold.*

Fruit weight

In the case of McIntosh, mean fruit weight was greater with the P18 rootstock than with either EM26 or V605-4 (Table 26). Closer examination of mean annual weight values, however, suggests that fruit weight declined as tree production increased.
No significant differences were observed for mean fruit weight in the case of McIntosh on EM26 compared to McIntosh on V605-4.
In the case of the cultivar Spartan, no significant differences in mean fruit weight were observed with any of the four rootstocks, O8, P18, EM26 and B491 (Table 27). With the first two of those rootstocks, O8 and P18, Spartan was similar to McIntosh in that mean annual fruit weight was found to decline as tree production increased.

Table 26.

Mean fruit weight* for McIntosh Summerland on three different rootstocks planted in 1996 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1998 (g)	1999	2000	2001	2002	2003	2004	2005	mean98-05
V605-4	183.13	142.60	148.26	148.56	122.02	184.96	146.68	125.92	149.27a
EM26	170.14	140.20	172.24	159.54	121.18	178.12	162.12	127.16	153.84a
P18	160.00	181.20	190.10	189.86	141.08	182.32	163.40	135.84	168.34b

Mean fruit weight* for Spartan on four different rootstocks planted in 1996 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1998 (g)	1999	2000	2001	2002	2003	2004	2005	mean98-05
Ottawa 8	186.24	205.60	132.30	164.30	174.08	133.88	125.40	106.40	153.52a
EM26	176.82	175.00	130.44	145.62	172.56	174.76	148.64	120.92	155.59a
Bud 491	163.26	174.40	145.60	161.64	164.44	181.68	133.04	127.04	156.39a
P18	182.75	190.60	137.26	178.61	166.32	161.04	131.40	118.92	158.36a

**mean weight of 10 fruits per production year*

**** Figures followed by the same letter show no significant differences at the 0.05 threshold.*

Analysis and discussion

The dwarf rootstock category included Vineland 605-4 and Budakovsky 491. V605-4 proved to be similar to EM26 in terms of vigour. However, it was found to be more advantageous than the latter rootstock in several respects: less prone to suckering, fewer burrknots, less freezing damage and better lignification. As regards yield, cumulative yield efficiency and fruit weight, our trial, which was conducted with McIntosh only, did not indicate that the V605-4 rootstock was superior to the EM26. The former should be subjected to trials at level 2 so that its cold tolerance and its performance with other cultivars can be evaluated. The good qualities identified to date—fewer suckers, fewer burrknots, less freezing damage and better lignification—might make this rootstock a good choice in the dwarf category for Quebec growers.

The B491 rootstock sustained less freezing damage, was better in terms of lignification, and produced fewer suckers and burrknots than the EM26. It was also more productive than the latter. Owing to its size, however, it must be assigned to a different category than the EM26, as it is more dwarfing than the B9. This rootstock is suitable for very high planting densities. As to whether it is in any way more advantageous than the B9, our trial did not enable us to decide, as the B9 rootstock was not included in the comparison . The B491 rootstock is not readily available, and it is not commonly planted in orchards throughout the world.

There was only one rootstock in the semi-dwarf category, namely Ottawa 8. O8 proved the equal of EM26 with respect to freezing and suckering. It was outperformed by EM26 as regards lignification, but appeared to improve when bearing age was reached. The O8 rootstock produced fewer burrknots than EM26. Full bearing age was not attained for seven to eight years. The O8 rootstock should be compared with MM106 and G30 to determine whether it is in any way preferable to them; however, the results of our trial suggest that it probably is not, at any rate as regards susceptibility to freezing and time required to reach bearing age. This rootstock is not commercially available.

There was only one rootstock in the vigorous category, namely Polish 18. P18 proved to possess a number of good qualities, such as cold tolerance and low burrknot production, but because it is so vigorous and late bearing, it is not a very promising rootstock for commercial apple growers in Quebec.

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Rootstock trial, 1997-2005

Descriptions of rootstocks:

Budakovsky 146, Budakovsky 490, C6, Malling 9T337, Malling 20, Polish 13 and Polish 14.

M20: Malling 20 or East Malling 20, a very dwarf rootstock originated at East Malling, England; has been little evaluated.

B146: Budakovsky 56-146, a very dwarf rootstock originated in Russia, early bearing, susceptible to fire blight and woolly apple aphid.

M9 T337: M9NAKBT.337, a clone of M9 that is less vigorous than EMLA9, introduced in the Netherlands, susceptible to fire blight and woolly apple aphid, phytophtora-resistant.

C6: a dwarf rootstock introduced by Stark Bros Nurseries & Orchards for use as an interstem, a chance seedling of M8, susceptible to fire blight, has been little evaluated.

P13: Polish 13, a semi-vigorous rootstock originated in Poland, M4 x Antonovka, has been little evaluated.

P14: Polish 14, a semi-vigorous rootstock originated in Poland, M9 x Antonovka, has been little evaluated.

B490: Budakovsky 57-490, a vigorous rootstock originated in Russia, cold-resistant, phytophtora-resistant, slightly susceptible to fire blight, susceptible to woolly apple aphid.

Vigour of McIntosh Summerland and Spartan on 8 rootstocks after having been grown for 8 years at AAFC, Frelighsburg, QC, Canada

	McIntosh		Spartan	
Rootstock	TCSA (cm^2)	/EM26	TCSA (cm^2)	/EM26
M20	7.01a	0.22	6.82a	0.28
Bud 146	11.17ab	0.35	6.78a	0.28
M9T337	24.85bc	0.79	17.10a	0.70
C6	25.71bc	0.81	18.94a	0.77
EM26	31.55c	1.00	24.40a	1.00
P14	73.02d	2.31	50.88b	2.10
P13	81.57d	2.58	66.34b	2.72
Bud 490	120.28e	3.81	95.7c	3.92

Figures followed by the same letter show no significant differences at the 0.05 threshold.

Cold resistance and lignification

An analysis of freezing indices enables us to assign the rootstocks evaluated in this trial to three groups on the basis of their susceptibility to cold (the indices found with both cultivars, McIntosh and Spartan, proved to be ranked in the same order). B146 proved to be the rootstock that was the most susceptible to cold, with higher freezing indices than EM26 or any of the others (tables 27 and 28). C6 and M20 fall into an intermediate group, with freezing indices similar to those observed for EM26. The three rootstocks with the best cold resistance were M9T337, P13 and P14, which had freezing indices that were lower than those observed for EM26 or any of the

other rootstocks except B490. The B490 rootstock, when grafted with McIntosh, had the lowest freezing indices of all, and when grafted with Spartan, proved comparable to EM26, with intermediate indices. Overall, freezing symptoms were slight for all these rootstocks: the sum of the annual freezing indices was under 10 in the case of all of them except B146.

An analysis of lignification indices reveals that with Spartan, the rootstocks fall into two groups: those that hardened off fairly well and may be ranked with EM26, and those that hardened off less well than EM26 (Table 30). The first group, comprising rootstocks with a cumulative index of between 62 and 69, contains C6, M20, B146 and EM26. The second group, comprising rootstocks with a cumulative index of between 76 and 88, contains M9T337, P13, P14 and B490. With McIntosh Summerland, the rootstocks are less sharply differentiated: all of them hardened off fairly well to moderately well (Table 29). The former group, with rootstocks having a cumulative index of between 65 and 69, contains C6, M20, B146 and M9T337. The latter group, with rootstocks having an index of between 71 and 73, contains EM26, P13, P14 and B490.

Table 27. Annual freezing indices* for the cultivar McIntosh Summerland on eight different rootstocks planted in 1997 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1998	1999	2000	2001	2002	2003	2004	2005
Bud 146	5	5	9	10	11	12	11	12
Bud 490	5	6	5	5	5	6	5	5
C6	5	5	7	5	6	7	9	8
EM26	5	5	7	5	5	9	7	7
M20	5	5	8	5	5	9	9	9
M9T337	5	5	5	5	7	6	7	5
P13	5	5	5	5	5	5	5	9
P14	5	5	6	5	5	6	9	5

**Sum of indices for 5 trees*
1 = no sign of freezing, 2 = freezing on terminal bud, 3 = necrosis on trunk and small branches, 4 = death of tree

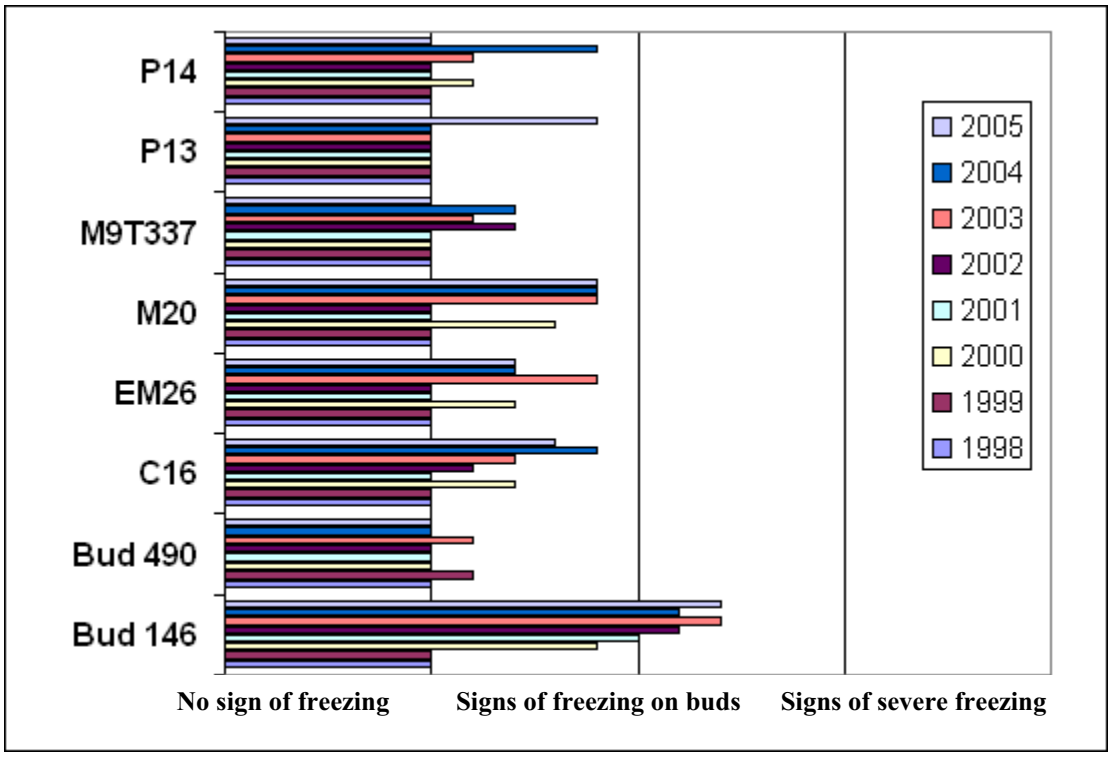


Table 28. Annual freezing indices* for Spartan on eight different rootstocks planted in 1997 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1998	1999	2000	2001	2002	2003	2004	2005
Bud 146	5	5	6	9	8	9	9	9
Bud 490	5	7	6	8	5	10	5	5
C6	5	5	8	5	6	9	8	9
EM26	5	5	8	5	5	10	8	6
M20	5	5	5	7	5	9	8	10
M9T337	5	5	5	5	7	8	6	6
P13	5	5	5	5	5	10	5	8
P14	5	5	5	6	5	10	7	6

**Sum of indices for 5 trees*

1 = no sign of freezing, 2 = freezing on terminal bud, 3 = necrosis on trunk and small branches, 4 = death of tree

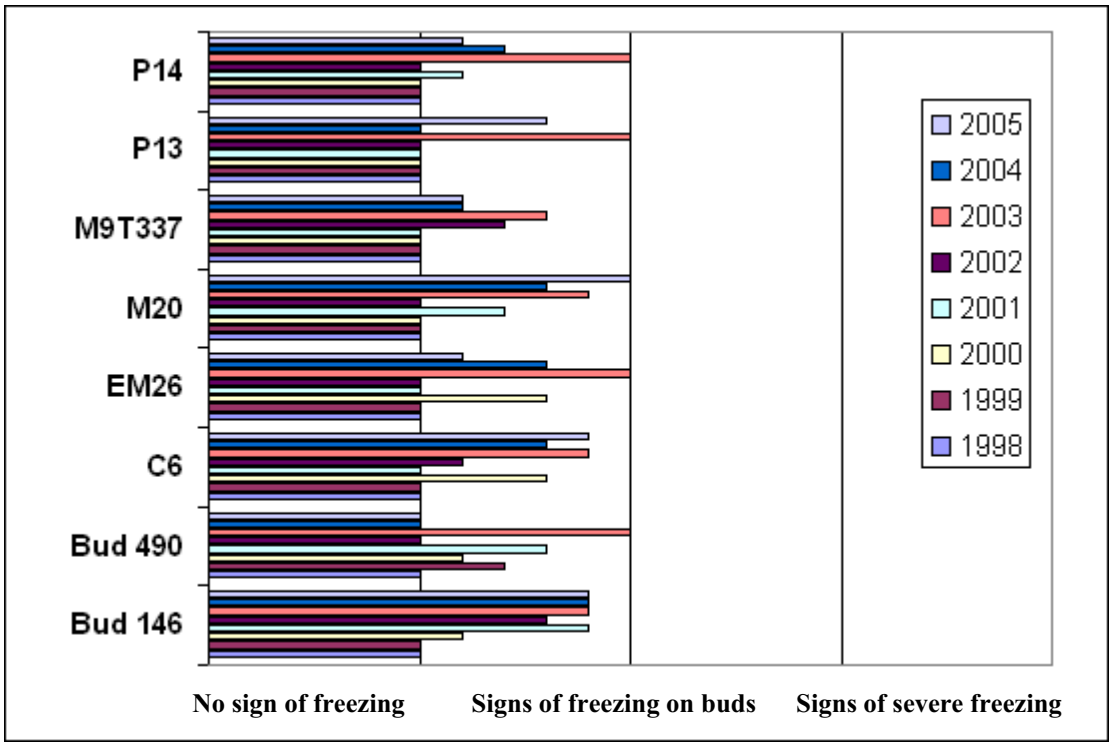


Table 29. Annual lignification indices* for the cultivar McIntosh Summerland on eight different rootstocks planted in 1997 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1997	1998	1999	2000	2001	2002	2003	2004	2005
B146	10	8	5	9	5	9	6	5	10
B490	7	10	5	15	6	9	5	8	6
C6	9	6	6	7	5	9	8	8	11
EM26	7	9	6	9	5	10	7	9	10
M20	5	8	5	8	5	12	9	5	8
M9T337	7	9	6	8	5	11	6	6	10
P13	5	10	10	15	6	9	5	5	7
P14	9	10	7	11	6	9	5	6	10

**Sum of indices for 5 trees*

1 = excellent, 2 = moderate, 3 = low

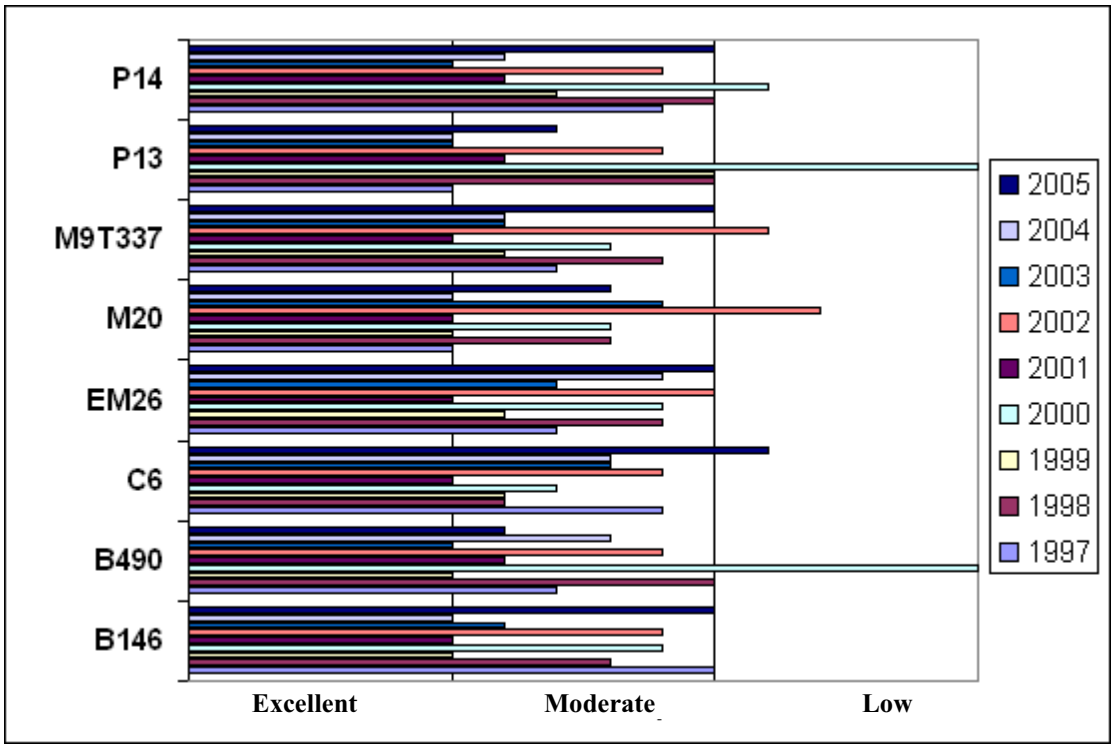
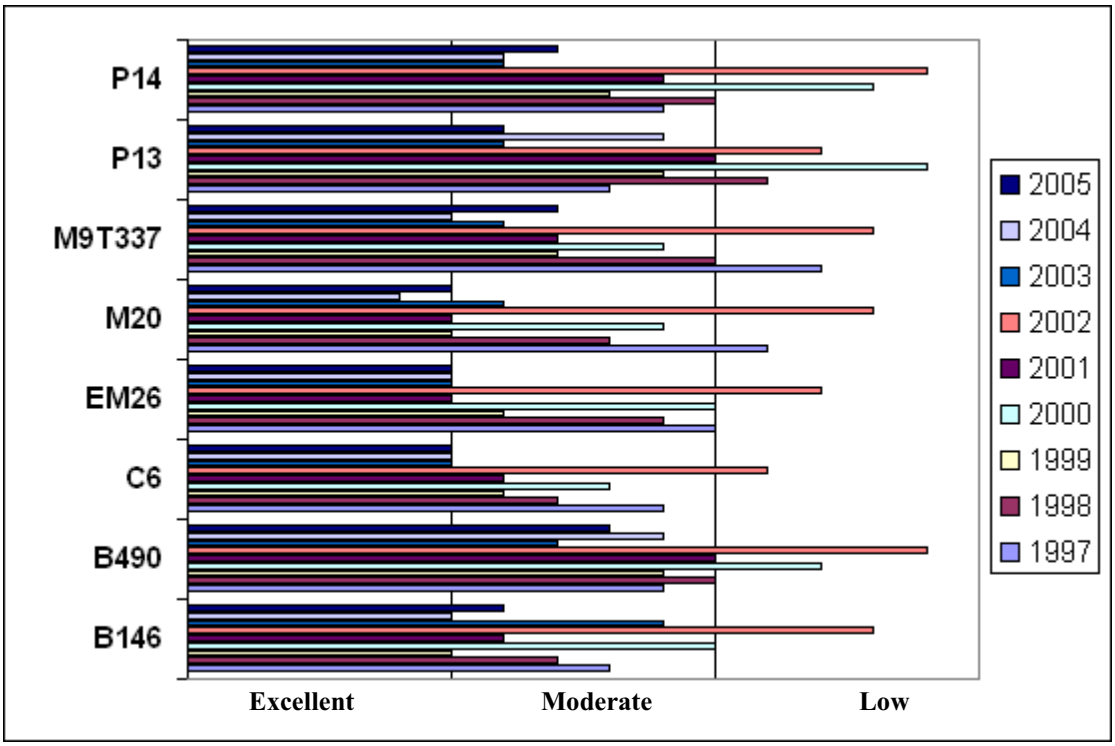


Table 30. Annual lignification indices* for the cultivar Spartan on eight different rootstocks planted in 1997 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1997	1998	1999	2000	2001	2002	2003	2004	2005
B146	8	7	5	10	6	13	9	5	6
B490	9	10	9	12	10	14	7	9	8
C6	9	7	6	8	6	11	5	5	5
EM26	10	9	6	10	5	12	5	5	5
M20	11	8	5	9	5	13	6	4	5
M9T337	12	10	7	9	7	13	6	5	7
P13	8	11	9	14	10	12	6	9	6
P14	9	10	8	13	9	14	6	6	7

**Sum of indices for 5 trees*

1 = excellent, 2 = moderate, 3 = low



Suckering and burrknots

The eight rootstocks included in this trial were equally prone to suckering, regardless of whether they were grafted with McIntosh or Spartan (tables 31 and 32). Some of them (B146 and M20) were more prone to suckering with McIntosh than with Spartan, but, as will be seen by comparing the results, the several rootstocks came out in the same order for both cultivars. Accordingly, each of them may be assigned to one of the groups listed below:
No suckers: B490
Few or very few suckers: P13, P14
Moderate numbers of suckers: C6
Many suckers: EM26, M9T337, M20, B146.

The eight rootstocks evaluated in this trial proved equally prone to burrknots, regardless of whether they were grafted with McIntosh or Spartan (tables 33 and 34). Some of them (B146

and EM26) were more prone to burrknots with Spartan than with McIntosh, but, as will be seen by comparing the results, the several rootstocks came out in the same order for both cultivars. Accordingly, each of them may be assigned to one of the groups listed below on the basis of their susceptibility to burrknot production:
Very slightly susceptible: B490, P13
Slightly susceptible: P14, C6
Moderately susceptible: M20, M9T337
Highly susceptible: EM26, B146.

Table 31. Annual suckering indices* for the cultivar McIntosh Summerland on eight different rootstocks planted in 1997 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1997	1998	1999	2000	2001	2002	2003	2004	2005
B146	5	6	11	10	12	13	15	15	15
B490	5	5	5	5	5	5	5	6	5
C6	5	5	7	6	8	9	9	9	9
EM26	5	7	8	9	10	9	11	11	10
M20	6	9	8	10	10	11	12	14	14
M9T337	5	9	10	7	10	11	13	12	12
P13	6	5	5	5	5	6	6	6	5
P14	5	5	5	5	7	6	6	7	8

Suckering index: *1. None*
2. Moderate
3. Severe

** Sum of indices from 5 replications.*

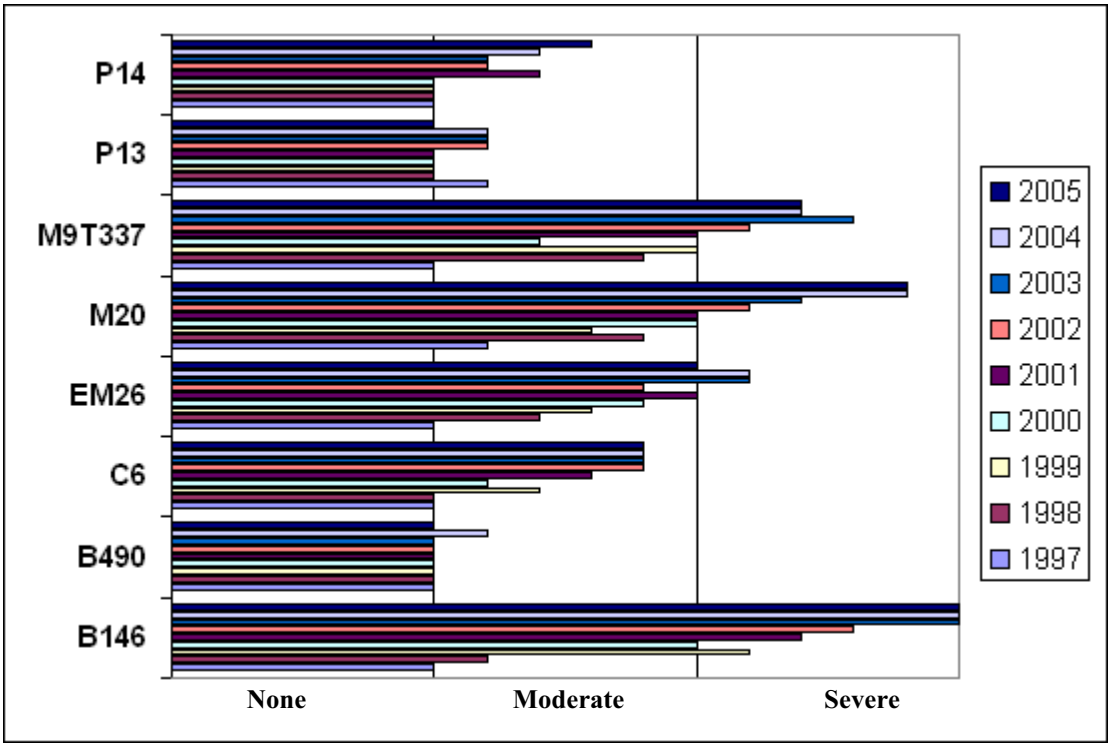


Table 32. Annual suckering indices* for the cultivar Spartan on eight different rootstocks planted in 1997 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1997	1998	1999	2000	2001	2002	2003	2004	2005
B146	7	5	12	9	9	8	15	15	15
B490	5	5	5	6	5	5	5	5	5
C6	6	7	10	5	7	6	11	12	11
EM26	5	7	10	8	8	11	10	13	13
M20	5	9	9	8	10	10	9	11	15
M9T337	5	7	9	6	11	11	15	14	14
P13	5	5	5	5	5	5	6	5	11
P14	5	5	5	5	6	7	7	9	12

Suckering index: *1. None*
2. Moderate
3. Severe

** Sum of indices from 5 replications.*

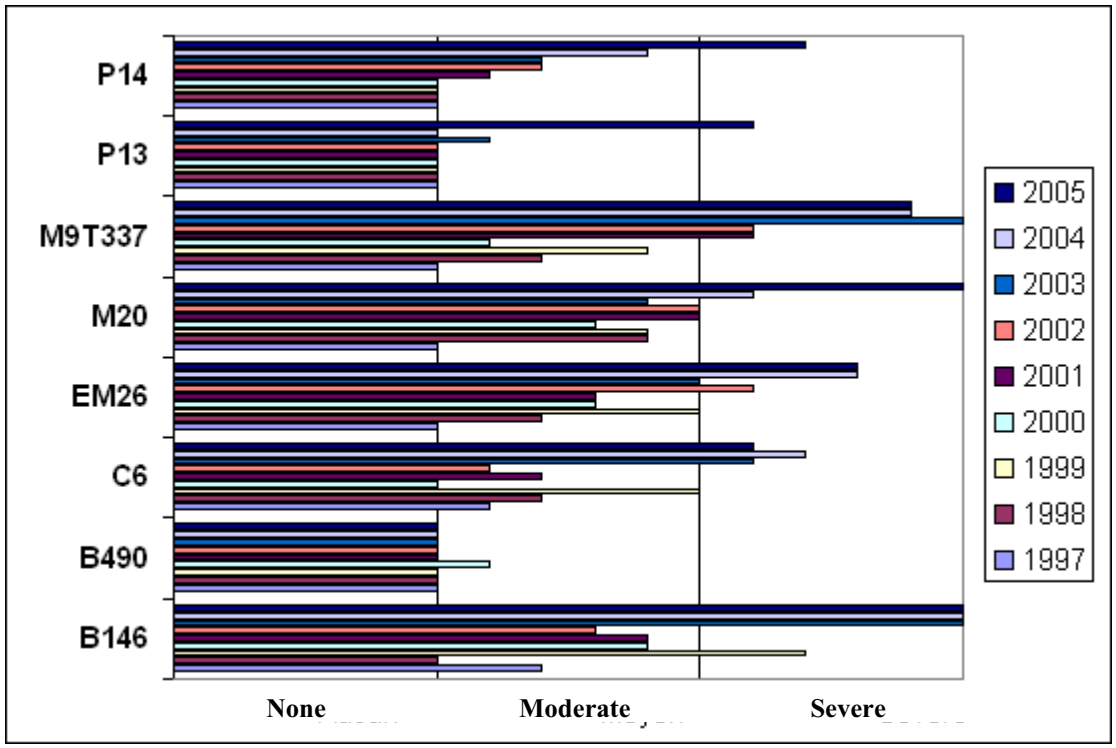


Table 33. Annual burrknot production indices* for the cultivar McIntosh Summerland on eight different rootstocks planted in 1997 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1997	1998	1999	2000	2001	2002	2003	2004	2005
B146	8	12	13	13	12	13	12	15	15
B490	5	5	6	5	5	5	5	5	6
C6	5	6	8	7	6	6	5	5	5
EM26	5	10	13	9	11	10	7	10	11
M20	6	12	14	10	12	9	7	8	11
M9T337	5	7	12	9	10	9	8	10	9
P13	5	5	5	5	5	5	5	7	7
P14	5	5	7	5	8	6	5	8	7

Burrknot production index: *1. Low*
2. Moderate
3. Severe

** Sum of indices from 5 replications.*

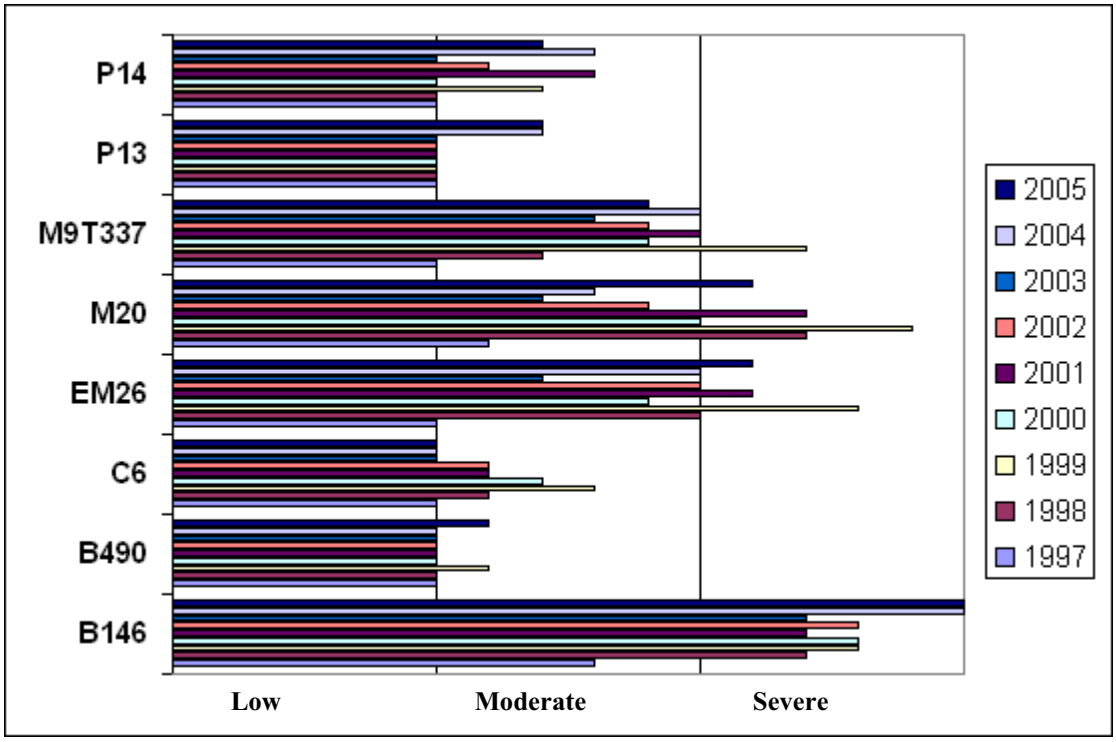
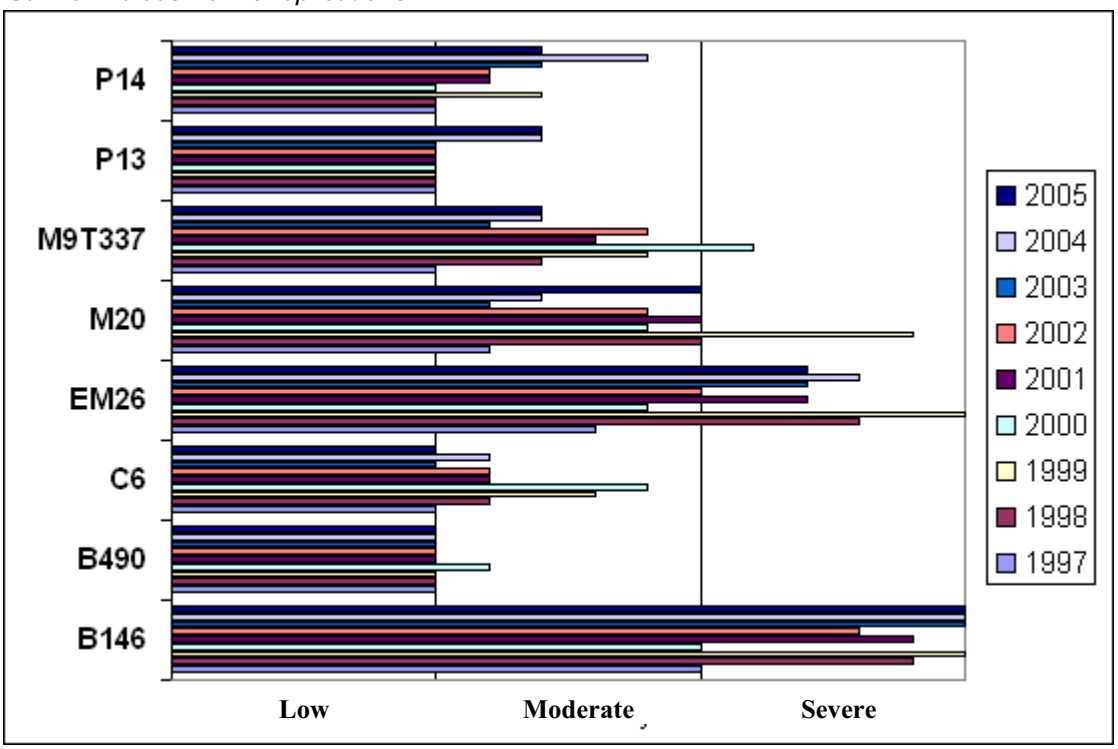


Table 34. Annual burrknot production indices* for the cultivar Spartan on eight different rootstocks planted in 1997 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1997	1998	1999	2000	2001	2002	2003	2004	2005
B146	10	14	15	10	14	13	15	15	15
B490	5	5	5	6	5	5	5	5	5
C6	5	6	8	9	6	6	5	6	5
EM26	8	13	15	9	12	10	12	13	12
M20	6	10	14	9	10	9	6	7	10
M9T337	5	7	9	11	8	9	6	7	7
P13	5	5	5	5	5	5	5	7	7
P14	5	5	7	5	6	6	7	9	7

Burrknot production index: *1. Low*
2. Moderate
3. Severe

** Sum of indices from 5 replications.*



Annual yield and productivity

None of the eight rootstocks evaluated in this trial showed any difference in productivity (cumulative yield efficiency, or CYE) when grafted with one of the cultivars (McIntosh and Spartan) rather than the other (Table 35). B490 came last, with a CYE that was lower than that of EM26 and those of all the other rootstocks except P13. M9T337 and M20 headed the list, with CYE values that were higher than that of EM26 and those of all the other rootstocks except B146.

The CYE values observed for P14, C6 and B146 were comparable to that of EM26 (no significant difference).

It would be desirable for the B490, P13 and P14 rootstocks to be evaluated over a longer period, as they attained full production toward the seventh or eighth year under orchard conditions and grew more slowly thereafter. They were later bearing than the smaller rootstocks.
The earliest-bearing (see Glossary, Appendix 1) rootstocks were M20 and C6, and the latest-bearing were P13 and B490.

Table 35. Annual yield (Y), cumulative yield (CY), vigour (TCSA) and productivity (CYE) for the cultivar McIntosh Summerland on eight rootstocks planted in 1997 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	Y 99 (kg)	Y 2000	Y 2001	Y 2002	Y 2003	Y 2004	Y 2005	CY	TCSA (cm^2)	CYE
Bud 490	0.31	5.51	11.45	8.54	46.64	68.04	75.38	215.88d	120.28e	1.80a
P13	0.15	2.22	8.26	10.71	42.29	60.24	73.15	197.02d	81.57d	2.41ab
P14	0.61	5.30	11.49	6.23	48.39	67.27	86.01	194.64d	73.02d	3.13abc
C6	2.28	6.67	9.28	4.45	22.26	17.39	21.98	84.31abc	25.71bc	3.49bc
EM26	1.25	6.47	8.87	7.61	29.57	24.88	38.85	117.49bc	31.55c	3.70c
Bud 146	1.46	3.82	4.85	2.64	6.34	12.22	15.15	48.11ab	11.17ab	4.18cd
M9T337	2.94	7.29	11.95	7.66	27.15	31.54	37.02	125.55c	24.85bc	5.33d
M20	2.23	3.86	3.77	3.83	8.51	7.00	9.26	36.60a	7.01a	5.81d

Annual yield (R), cumulative yield (CY), vigour (TCSA) and productivity (CYE) for the cultivar Spartan on eight different rootstocks planted in 1997 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	Y 99 (kg)	Y 2000	Y 2001	Y 2002	Y 2003	Y 2004	Y 2005	CY	TCSA (cm^2)	CYE
Bud 490	0.53	8.23	16.13	7.41	36.78	53.10	54.95	177.13c	95.7c	1.94a
P13	0.69	4.31	7.15	11.57	40.07	41.70	36.72	142.21c	66.34b	2.15ab
P14	1.74	7.54	14.81	13.22	35.64	47.73	36.03	156.70c	50.88b	3.16bc
C6	3.00	6.16	5.57	7.38	19.92	14.86	15.17	72.07ab	18.94a	3.65cd
EM26	3.26	7.45	7.08	8.93	19.99	18.49	29.34	94.54b	24.40a	3.90cd
Bud 146	1.30	2.06	2.80	1.50	6.18	6.24	10.15	30.23a	6.78a	4.59de
M9T337	3.18	6.02	7.92	7.50	20.11	22.40	20.38	87.51b	17.10a	5.15e
M20	1.84	2.63	3.04	3.96	8.87	7.31	7.38	35.03a	6.82a	5.46e

Y = mean yields for 5 trees
CY = sum of Y values, 1999-2005
TCSA = trunk cross-sectional area at a height of 30 cm
CYE = CY/TCSA
** Figures followed by the same letter show no significant differences at the 0.05 threshold.*

Fruit weight

Mean fruit weight for the P14 rootstock grafted with McIntosh Summerland was significantly greater than in the case of the EM26 rootstock grafted with the same cultivar (Table 36). The fruits produced with the B146 and M20 rootstocks were significantly smaller than those produced with EM26. Mean fruit weight for the C6, M9T337, P13 and B490 rootstocks was not significantly different from the value observed for EM26.
When the cultivar Spartan was used, significantly larger fruits were obtained from the P14 rootstock than from EM26 (Table 36). The fruits from the B146 rootstock were significantly smaller than those from EM26. No significant difference was observed between fruits obtained from the M20, P13, C6, M9T337 and B490 rootstocks and those obtained from EM26.

Table 36. Mean fruit weight* for McIntosh Summerland grafted on eight different rootstocks planted in 1997 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1999 (g)	2000	2001	2002	2003	2004	2005	mean99-05
Bud 146	137.50	156.30	144.90	123.27	171.42	141.00	122.13	137.88a
M20	158.15	153.56	157.20	117.94	169.04	136.24	103.80	143.47ab
C16	137.45	148.94	155.76	122.36	182.56	151.44	135.12	147.66abc
M9T337	167.80	173.46	159.48	117.86	181.28	160.60	129.20	155.67bcd
EM26	150.63	172.62	171.40	122.36	195.00	165.16	129.36	158.08cd
P13	185.00	185.60	183.98	133.54	182.56	145.08	121.92	159.57cde
Bud 490	162.78	190.29	193.14	136.68	186.20	152.52	129.76	164.72de
P14	180.33	196.95	191.18	132.54	185.92	165.45	139.55	172.14e

Mean fruit weight* for Spartan grafted on eight different rootstocks planted in 1997 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1999 (g)	2000	2001	2002	2003	2004	2005	mean99-05
Bud 146	217.26	137.26	126.12	156.92	166.80	112.00	102.20	145.51a
M20	210.91	141.22	142.51	175.70	166.28	125.28	113.95	155.08ab
P13	218.44	149.06	163.45	164.86	177.48	106.02	121.88	155.57ab
C16	225.61	144.00	168.55	185.98	163.80	139.52	120.35	163.09bc
EM26	230.44	141.28	160.08	173.72	168.52	159.52	113.92	163.93bc
M9T337	240.20	161.84	150.44	172.23	192.92	146.80	124.40	169.83cd
Bud 490	229.17	178.20	167.93	158.83	197.05	149.15	119.80	175.48cd
P14	267.44	173.94	169.02	172.08	196.96	143.84	122.56	177.98d

**mean weight of 10 fruits per production year*

**** Figures followed by the same letter show no significant differences at the 0.05 threshold.*

Analysis and discussion

Two of the rootstocks, M20 and B146, belong to the "very dwarfing" category. In terms of cumulative yield efficiency, B146 was comparable to EM26 and M9T337. It was prone to suckering and burrknots, and was not cold-resistant. This rootstock, which is smaller than B9, does not represent any improvement over rootstocks that are already commercially available. Accordingly, we see no point in further evaluation of it with a view to a recommendation.

The M20 rootstock, which is also smaller than B9, was earlier bearing than EM26 and had a higher cumulative yield efficiency. However, it was just as susceptible to cold as EM26, and consequently does not represent any improvement in that respect. It was prone to suckering and produced as many burrknots as M9T337. It is not commercially available. Accordingly, we see no point in further evaluation of it with a view to a recommendation.

Two of the rootstocks, M9T337 and C6, belong to the "dwarf" category. The main advantage of M9T337 was its productivity (CYE), which was higher than that of EM26. It is smaller than EM26, and hence can be planted at higher densities, producing greater yields per hectare. M9T337 was found to be slightly less cold-sensitive than EM26. In the course of the 1995-2002 rootstock trial, EMLA9 was found to be less cold-sensitive than EM26 when grafted with McIntosh, and as cold-sensitive as EM26 when grafted with Spartan. Level 2 university trials found that M9 was less cold-sensitive than EM26 on southern Quebec sites, but more cold-sensitive in the Quebec City region. Findings to date from a level 1 trial currently under way indicate that two subclones of M9, Pajam 1 and Pajam 2, are either less cold-sensitive than, or as cold-sensitive as, EM26.

The main defects of M9T337 were its tendency to produce large numbers of suckers (it was equal to EM26 in that respect) and burrknots (to which it was slightly less prone than EM26). Our results from the 1995-2002 rootstock trial were similar as regards the tendency of the EMLA9 rootstock to produce suckers and burrknots, and findings to date from a trial currently under way point to the same tendency for four subclones of M9, Pajam 1 and 2 and Nicolai 19 and 29.

The C6 rootstock, which is similar in size to M9T337 or slightly larger, produced fewer suckers than either EM26 or M9T337 and few burrknots. However, this rootstock proved to be just as cold-sensitive as EM26, while in terms of productivity it was inferior to M9T337 but on a par with EM26. The cultivars grafted on this rootstock were early bearing, but yields flattened out at a level below that of M9T337, making it less productive. In the light of these results, it appears that this rootstock is hardly more advantageous than EM26 and M9T337. In any case, it is very rarely used, and its commercial availability is minimal to nonexistent.

Two rootstocks, P14 and P13, belong to the "semi-vigorous" category. Both of them are larger than MM106 and M7. P13 was found to be slightly more vigorous than P14. The main good features of these two rootstocks were cold resistance, the fact that they were not prone to suckering or burrknots, and, in the case of P14, larger fruit size. In terms of productivity and cumulative yield, there were no significant differences between P13 and P14, but the latter produced larger fruits than the former and was slightly earlier bearing. Mean fruit weight for P14 was significantly greater than for EM26. However, fruit weight tended to diminish once the trees had attained full maturity and yields had stabilized.

Because these two rootstocks are so vigorous, they would not be suitable for intensive orchards. Both of them, but P14 in particular, might be advantageous in regions where hardiness was of prime importance.

One rootstock, B490, belongs to the vigorous category. This rootstock had the lowest freezing index of all those evaluated in this trial when grafted with McIntosh, and was equal to EM26 in that respect when grafted with Spartan. Its cumulative lignification index was comparable to that of EM26, and it produced almost no suckers at all and very few burrknots. B490 was found to be less productive than any of the other rootstocks evaluated in the trial except P13, as it was so vigorous that it produced very little fruit in relation to its volume during at least seven years under orchard conditions.

Despite its good qualities, this rootstock was much too vigorous to be of interest to growers.

Rootstock trial, 1998-2005

Description of rootstock:

O8: Ottawa 8, a semi-dwarf rootstock, vigour 2.16 x EM26, originated at Ottawa, Canada, Malus baccata gracilis x EM7 cross, little known.

McIntosh Summerland grafted on O8 was compared with McIntosh Summerland grafted on EM26.

Cold resistance and lignification

McIntosh on O8 sustained freezing damage equal to or greater than McIntosh on EM26 (Table 37). Freezing damage was observed for this rootstock in every year in which the temperature fell below -30°C, i.e. in 2000, 2003, 2004 and 2005.

Lignification indices for O8 were similar to or slightly higher than those observed for EM26 (Table 38).

Table 37. Annual freezing indices* for the cultivar McIntosh Summerland on two different rootstocks planted in 1998 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1999	2000	2001	2002	2003	2004	2005
EM26	5	6	5	7	7	7	8
O8	5	6	5	5	13	9	9

**Sum of indices for 5 trees*
1 = no sign of freezing, 2 = freezing on terminal bud, 3= necrosis on trunk and small branches, 4 = death of tree

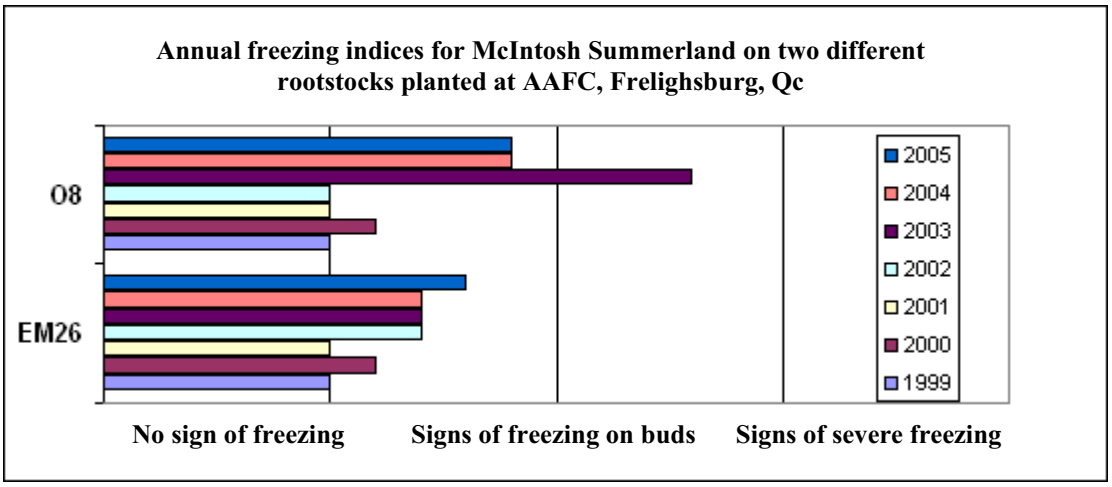
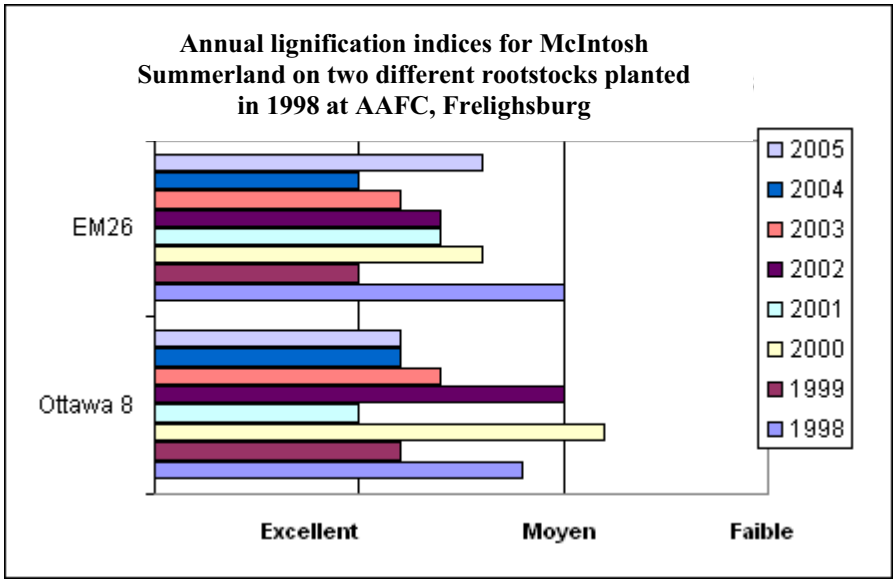


Table 38. Annual lignification indices* for the cultivar McIntosh Summerland on two different rootstocks planted in 1998 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1998	1999	2000	2001	2002	2003	2004	2005
Ottawa 8	9	6	11	5	10	7	6	6
EM26	10	5	8	7	7	6	5	8

**Sum of indices for 5 trees*
1 = excellent, 2 = moderate, 3 = low



Suckering and burrknots

When grafted with McIntosh, the O8 rootstock produced no suckers in the first three years, thereafter exceeding EM26 with severe sucker production each year (Table 39).

O8 produced slightly fewer burrknots than EM26 in the first three years, thereafter exceeding the latter by producing substantial numbers of them every year (Table 40).

Table 39. Annual suckering indices* for the cultivar McIntosh Summerland on two different rootstocks planted in 1998 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1998	1999	2000	2001	2002	2003	2004	2005
Ottawa 8	5	5	5	13	15	15	15	15
EM26	8	9	5	7	8	9	12	8

Suckering index: *1. None*
2. Moderate
3. Severe

** Sum of indices from 5 replications.*

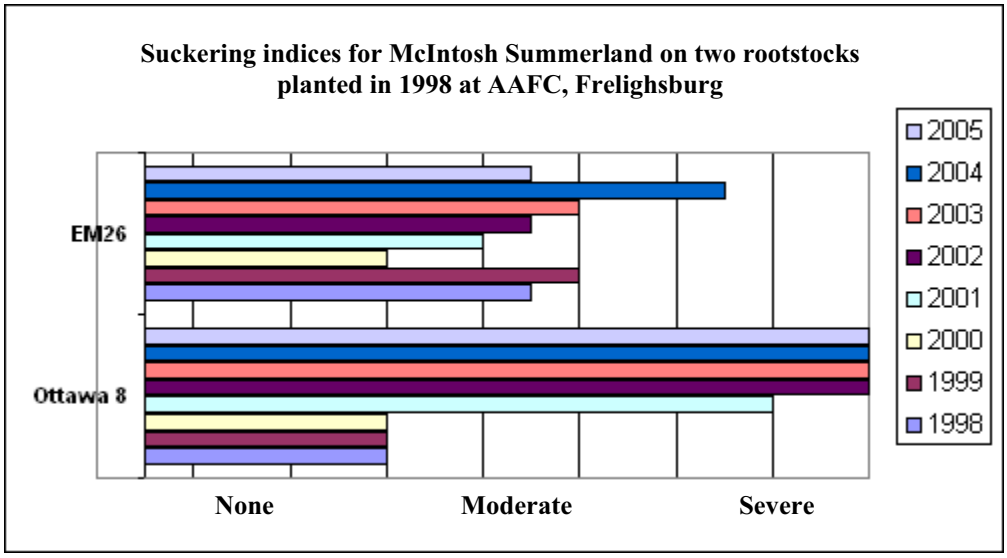
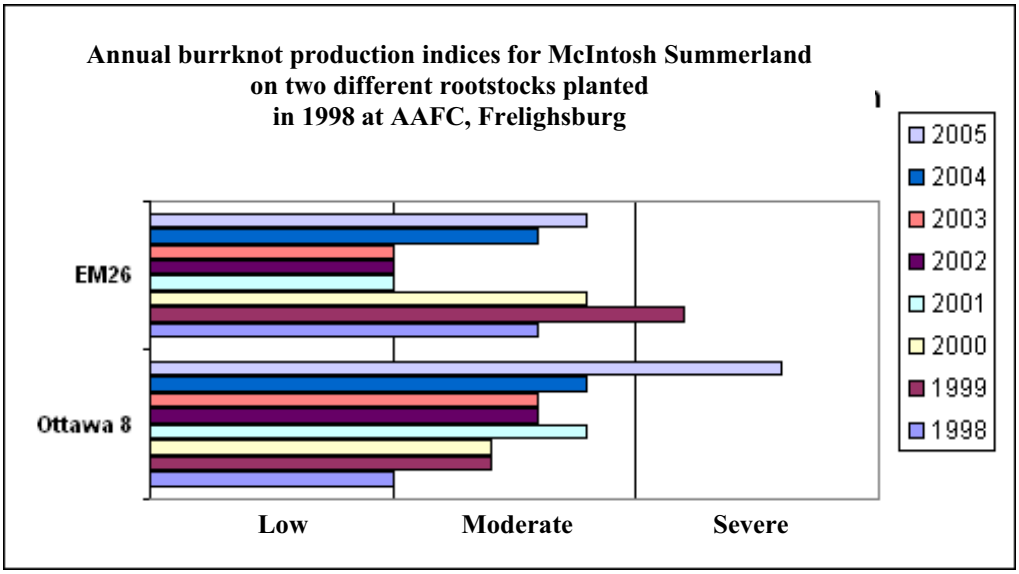


Table 40. Annual burrknot production indices* for the cultivar McIntosh Summerland on two different rootstocks planted in 1998 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	1998	1999	2000	2001	2002	2003	2004	2005
Ottawa 8	5	7	7	9	8	8	9	13
EM26	8	11	9	5	5	5	8	9

Burrknot production index: *1. Low*
2. Moderate
3. Severe

** Sum of indices from 5 replications.*



Annual yield and productivity

No significant difference between the O8 and EM26 rootstocks was observed in terms of their respective productivity (cumulative yield efficiency) indices (Table 41), although CYE was slightly higher in the case of EM26. O8 is a semi-dwarf rootstock with a vigour index (TCSA) that was superior to that of EM26 and annual yields (Y) that exceeded those of EM26 beginning in the sixth year under orchard conditions. McIntosh on O8 was early bearing.

Table 41. Annual yield (Y), cumulative yield (CY), vigour (TCSA) and productivity (CYE) for the cultivar McIntosh Summerland on two different rootstocks planted in 1998 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	R 2000 (kg)	Y 2001	Y 2002	Y 2003	Y 2004	Y 2005	CY	TCSA (cm^2)	CYE
O8	3.85	11.09	2.54	21.69	30.86	33.02	103.04b	46.86b	2.25a
EM26	3.09	4.83	1.83	11.70	17.81	29.33	68.58a	21.66a	3.25a

Y = mean yield for 5 trees
CY = sum of Y values, 2000-2005
TCSA = trunk cross-sectional area at a height of 30 cm
CYE = CY/TCSA
** Figures followed by the same letter show no significant differences at the 0.05 threshold.*

Fruit weight

Mean fruit weight was lower for McIntosh on O8 than for McIntosh on EM26 (Table 42).

Table 42. Mean fruit weight for McIntosh Summerland on two different rootstocks planted in 1998 at AAFC, Frelighsburg, Quebec, Canada

Rootstock	2000 (g)	2001	2002	2003	2004	2005	mean00-05
O8	186.40	176.88	112.92	156.12	138.68	113.68	145.77a
EM26	187.42	177.46	140.88	189.36	171.24	128.84	165.87b

** mean weight of 10 fruits per production year*
**** Figures followed by the same letter show no significant differences at the 0.05 threshold.*

Analysis and discussion

The results of this trial with McIntosh grafted on Ottawa 8 supplemented the results obtained with Spartan grafted on the same rootstock during the period 1996-2005. In the course of these two trials, O8 was found to be more cold-sensitive than the EM26 rootstock, and it hardened off less well. It was also prone to suckering and burrknots. It produced fewer burrknots than EM26 when grafted with Spartan but more when grafted with McIntosh, and it produced more suckers than EM26 when grafted with McIntosh and just as many as EM26 when grafted with Spartan. Its productivity was equal or inferior to that of EM26, and its fruits were similar to or smaller than the fruits produced with EM26 when grafted with Spartan, and smaller than the latter's fruits when grafted with McIntosh.

The combined results of these two trials appear to indicate that the Ottawa 8 rootstock is no improvement on the existing range of currently available semi-dwarf rootstocks. O8's sensitivity

to cold, only moderately good lignification, small fruits and tendency to produce many suckers and burrknots are all weaknesses. This cannot be regarded as a promising rootstock.

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Appendix 1. Glossary

Burrknot production index: qualitative evaluation of a rootstock's tendency to produce burrknots. A point score of 1 for no burrknots, 2 for moderate burrknot production and 3 for severe burrknot production is assigned to every tree in the autumn of each year. The cumulative index is the total of the annual indices for five replications.

Cold storage life: maximum period following the harvest date during which fruits can be kept in a refrigerated chamber at 4°C.

Cumulative yield: the sum of a selection's annual yields, the annual yield being the total weight of fruit produced per tree. Mean value for five replications.

Earliness: the earlier bearing a cultivar is, the sooner its yield approaches the optimal value. Can be quantified and compared by calculating the second-year yield/optimal yield.

Flowering index: indicates the flowering period relative to the control cultivar, McIntosh Summerland : – before, = at the same time, + after.

Freezing index: qualitative visual evaluation of freezing damage on a tree. A point score of 1 is assigned for no sign of freezing, 2 for freezing of terminal buds, 3 for freezing of terminal buds accompanied by necrosis on the wood, 4 for the death of the tree. The point score is assigned to every tree annually in the spring. The cumulative index is the total of the annual indices for five replications.

Lignification index: qualitative evaluation of the extent to which a tree has hardened off as of November 15 in each year. The signs observed are cessation of growth of terminal buds, colouring, and leaf fall. A point score of 1 for excellent, 2 for moderate and 3 for low is assigned to every tree. The cumulative index for a cultivar or rootstock is the total of the annual indices for five replications.

Pressure index: pressure is measured twice for each fruit, once on each side, by means of a hand-held penetrometer with an 11-mm tip. Mean value of measures taken on 10 fruits selected at random. To convert to pounds, multiply by 2.205.

Productivity index: cumulative yield divided by vigour index (see below). This index is an indicator of how efficient the tree is in producing fruit, i.e. its fruit yield in relation to the space it occupies in the orchard. Also known as *cumulative yield efficiency* (CYE = CY/TCSA).

Ripeness index: indicates the extent to which the starch in the fruit has been converted to sugar. Measured by the colouring of the flesh after spraying with an iodine solution. Interpreted in accordance with the universal ripeness chart developed at Cornell University in New York State: 1 = 100% starch and 8 = 0% starch. The point score assigned is the mean value for measures taken on 10 fruits selected at random.

Suckering index: qualitative evaluation of a rootstock's tendency to produce suckers from the root. A point score of 1 for none, 2 for moderate and 3 for severe is assigned to every tree in the autumn of each year. All suckers that are observed are subsequently pruned. The cumulative index is the total of the annual indices for five replications.

Sugar index: the solid soluble (mainly sugars) concentration in the juice of an apple is measured by means of a manual refractometer (Atago Co., Tokyo) and is represented in degrees Brix. Mean value of measures taken on 10 fruits selected at random. The higher the value, the more sugar the juice contains.

Vigour index: represents the cross-sectional area of the trunk in cm^2 at a height of 30 cm above ground level. This value is calculated from the measured circumference of the trunk at a height of 30 cm above ground level, i.e. 15 cm (± 2 cm) above the graft. This index is a good indicator of tree size, i.e. the space the tree occupies in the orchard. Equivalent to *trunk cross-sectional area* (TCSA). Mean value for five replications.

Appendix 2. Winter temperatures

Maximum, minimum and mean temperatures for the winter months, 1996-2005, at the Agriculture and Agri-Food Canada experimental farm, Frelighsburg, Quebec, Canada

Year	Month	Maximum	Minimum	Mean
1996	November	21.7	-16.8	-0.5
1996	December	13.0	-23.2	-0.4
1997	January	8.9	-30.6	-8.8
1997	February	10.3	-24.0	-5.8
1997	March	15.6	-20.2	-3.8
1997	April	21.9	-11.0	4.31
1997	November	17.1	-8.8	1.0
1997	December	6.6	-22.0	-5.2
1998	January	8.8	-27.5	-6.6
1998	February	12.2	-23.3	-2.9
1998	March	25.3	-21.9	-0.4
1998	April	22.5	-4.8	7.3
1998	November	15.4	-7.9	3.4
1998	December	18.8	-27.9	-1.0
1999	January	13.2	-31.2	-8.1
1999	February	16.2	-22.2	-4.5
1999	March	16.3	-19.6	-1.5
1999	April	19.6	-5.4	5.4
1999	November	20.6	-9.2	5.0
1999	December	5.6	-15.1	-3.1
2000	January	14.2	-30.4	-10.2
2000	February	18.8	-28.3	-4.5
2000	March	21.8	-14.1	2.8
2000	April	23.1	-8.1	5.0
2000	November	17.8	-14.0	2.0
2000	December	11.6	-23.0	-8.6
2001	January	1.4	-25.1	-8.5
2001	February	9.4	-24.4	-7.6
2001	March	10.4	-22.9	-3.3
2001	April	26.0	-4.9	6.2
2001	November	20.6	-7.9	5.4
2001	December	18.5	-15.3	-0.3
2002	January	9.4	-17.5	-3.7
2002	February	14.6	-20.2	-4.3
2002	March	18.9	-14.8	-0.9
2002	April	29.0	-9.0	6.9
2002	November	22.0	-13.5	1.1
2002	December	8.6	-22.5	-4.7
2003	January	4.9	-32.0	-12.3
2003	February	5.9	-31.8	-10.0
2003	March	19.5	-26.7	-2.4
2003	April	26.4	-14.7	4.6
2003	November	17.9	-11.6	2.8
2003	December	11.7	-21.3	-4.4

2004	January	8.1	-35.0	-15.3
2004	February	7.0	-27.0	-8.3
2004	March	17.9	-17.2	0.2
2004	April	27.0	-9.4	5.8
2004	November	15.8	-12.3	1.9
2004	December	11.4	-29.6	-6.0
2005	January	15.0	-31.1	-10.7
2005	February	10.8	-23.0	-6.7
2005	March	14.5	-17.9	-3.5
2005	April	23.5	-4.7	6.8
2005	November	19.0	-12.8	3.2

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Appendix 3. Fruit data sheets.
1997-2003 trial *** see photographs of fruits in Appendix 4***

Name:	**Emerald Spire**				
Code:	T71				
Year planted:	1997				
Surface colour:	-50% pink blush				
Ground colour:	green				
Shape:	flattened round				
Colour of flesh:	white				
Texture of flesh:	juicy, crisp				
Flavour:	acid, bland, fair				
YEAR	1999	2000	2001	2002	2003
Date harvested	Oct. 1	Sept. 28	Sept. 26	Sept. 24	Sept. 24
Ripeness index	.	5	6	4	4
Harvest pressure (kg)	.	6	5.9	6.8	6.6
Harvest Brix	.	11.6	11.4	14.2	12.7
Harvest acidity	.	.	.36	.	.
Fruit weight (g)	.	217.5	135.3	166.54	203.64
Remarks, harvest	all fruits had fallen		ripeness and size uneven, not very firm, lacking in sugar	russeting and corky spots	sweet, acid, fair flavour
Pressure 1 month (kg)				4.9	4.7
Brix 1 month				13.6	13.9
Remarks, 1 month				aromatic, sweet, acid, flavour not of much interest	lacking in firmness

Name:	**Scarlet Spire**				
Code:	T 72				
Year planted	1997				
Surface colour:	50-90% red blush				
Ground colour:	green				
Shape:	round				
Colour of flesh:	greenish white				
Texture of flesh:	juicy				
Flavour:	sweet, bland, fair to poor				
YEAR	1999	2000	2001	2002	2003
Date harvested	Sept. 15	Sept. 28	Oct. 3	Oct. 8	Oct. 10
Ripeness index	6	7	8	8	7
Harvest pressure (kg)	7.5	6.9	7.3	7	6.8
Harvest Brix	11.6	11.1	11.2	12.2	11.9
Harvest acidity	.	.	0.54	.	.
Fruit weight (g)	137.41	150.36	143.36	108.25	155.88
Remarks, harvest	McI type, green apple flavour	sweeter and more acid than 1999	hint of bitterness, misshapen at stalk, lacking in firmness, skin thick, flesh not very crisp, flavour not of much interest	hint of bitterness	hint of bitterness
Pressure 1 month (kg)			5.9		
Brix 1 month			11.5		
Remarks, 1 month					

Name:	**Ottawa-654** (no photo)				
Code:	R53				
Year planted:	1997				
Surface colour:	-50% orange-red blush				
Ground colour:	yellowish green				
Shape:	round				
Colour of flesh:	cream				
Texture of flesh:	juicy, crisp				
Flavour:	acid, sweet, good to fair				
YEAR	1999	2000	2001	2002	2003
Date harvested	Sept. 26	Sept. 26	Sept. 20	Sept. 24	Sept. 17
Ripeness index	6	5	5	4	4
Harvest pressure (kg)	6.04	6.6	7.2	7.1	7.4
Harvest Brix	13.9	13.4	12.5	14.3	12.8
Harvest acidity	.	.	0.62		.
Fruit weight (g)	232.48	241.76	177.46	190.02	165
Remarks, harvest	pear-apple flavour, large yellow fruit	shape and size variable	skin thick, ripeness uneven, slightly soft		ripeness very uneven, fruits falling, too acid, flavour not of much interest
Pressure 1 month (kg)			5.1	6.3	5.6
Brix 1 month			14.2	14.5	13.4
Remarks, 1 month			soft, unpleasant taste	acid, sweet, unpleasant taste	lacking in firmness, not very sweet, not of much interest

Name:	**Ottawa-662**				
Code:	R52				
Year planted:	1997				
Surface colour:	+90% very dark red blush				
Ground colour:	green				
Shape:	round				
Colour of flesh:	white				
Texture of flesh:	juicy				
Flavour:	acid, sweet, bland, fair to poor				
YEAR	1999	2000	2001	2002	2003
Date harvested	Sept. 16	Sept. 26	Oct. 3	Oct. 9	Oct. 14
Ripeness index	2	3	7	4	4
Harvest pressure (kg)	7.41	7.3	7.7	6.9	6.3
Harvest Brix	11.41	11	10.9	14	12.4
Harvest acidity	.	.	.	.	.
Fruit weight (g)	158.49	198.71	125.42	151.59	131.48
Remarks, harvest	sugar water taste, skin thick		not of much interest, flavour bland	soggy breakdown, unpleasant taste, not much pressure	sweet, juicy, slightly aromatic, not much pressure
Pressure 1 month (kg)					6.3
Brix 1 month					12.8
Remarks, 1 month					unpleasant taste

Name:	**Ottawa-665**				
Code:	R54				
Year planted:	1997				
Surface colour:	+90% red blush				
Ground colour:	green				
Shape:	attenuate toward the calyx (Red Delicious shape)				
Colour of flesh:	cream				
Texture of flesh:	juicy, crisp				
Flavour:	acid, sweet, fair				
YEAR	1999	2000	2001	2002	2003
Date harvested	Oct. 7	Oct. 3	Oct. 3	Oct. 15	Oct. 14
Ripeness index	6	3	6	6	4
Harvest pressure (kg)	6.2	7.2	6.9	6.6	5.4
Harvest Brix	13.4	12.4	11.9	12	14.2
Harvest acidity	.	.	.	.	.
Fruit weight (g)	274.15	269.84	194.9	156.18	221.8
Remarks, harvest	heart watery		skin thick, not much pressure, not of much interest, doughy, boring, hardly sweet at all		heart watery, misshapen
Pressure 1 month (g)				4.7	4.9
Brix 1 month				11.8	15.3
Remarks, 1 month				soft, devoid of interest	doughy, unpleasant taste

Name:	**Ottawa-6412**				
Code:	R51				
Year planted:	1997				
Surface colour:	50-90% red-streaked				
Ground colour:	green				
Shape:	round				
Colour of flesh:	greenish white				
Texture of flesh:	crisp				
Flavour:	acid, astringent, unpleasant				
YEAR	1999	2000	2001	2002	2003
Date harvested	Oct. 4	Sept. 26	Sept. 20	Sept. 24	Sept. 24
Ripeness index	7	6	7	5	5
Harvest pressure (kg)	7.5	7.8	8.7	8.8	8
Harvest Brix	14	12.4	11.8	12.9	11.5
Harvest acidity	.	.		.	.
Fruit weight	123.93	150.84	118.8	125.3	103.28
Remarks, harvest	not much sugar	unpleasant	texture spongy, sweet, acid, astringent		acid, very unpleasant, devoid of interest
Pressure 1 month (kg)				7.9	7.7
Brix 1 month				13.4	11.7
Remarks, 1 month				unpleasant taste	same remark as at harvest

Name:	**Ottawa-6413**				
Code:	R55				
Year planted:	1997				
Surface colour:	50-90% red-streaked				
Ground colour:	green				
Shape:	round				
Colour of flesh:	white				
Texture of flesh:	juicy, crisp				
Flavour:	acid, aromatic, fair				
YEAR	1999	2000	2001	2002	2003
Date harvested:	Oct. 4	Oct. 3	Oct. 3	Oct. 9	9 oct.
Ripeness index	7	6	7	6	8
Harvest pressure (kg)	6.5	6.7	7.8	6.6	6.7
Harvest Brix	13.1	12.4	11.3	13.9	11
Harvest acidity		0.7	.		
Fruit weight (g)	235.35	168.26	124.5	177.38	109.76
Remarks, harvest		Cortland type, size variable, unpleasant taste	skin thick, Mcl type, not much pressure, sweet, acid, soggy breakdown	soggy breakdown	
Pressure 1 month (kg)		6.7			5.7
Brix 1 month		12.1			11.2
Remarks, 1 month		Cortland type, crisp, juicy, good			

1998-2004 trial *** see photographs of fruits in Appendix 5 ***

Name:	**Fayette**				
Code:	T82				
Year planted:	1998				
Surface colour:	+90% red-streaked				
Ground colour:	green				
Shape:	round				
Colour of flesh:	white				
Texture of flesh:	crisp				
Flavour:	acid				
YEAR	2000	2001	2002	2003	2004
Date harvested	Sept. 5	Aug. 30	Sept. 4	Sept. 2	Aug. 31
Ripeness index	5	5	4	3	7
Harvest pressure (kg)	6.2	7.3	7.6	7.7	6.8
Harvest Brix	10.8	12.9	12.3	11	10.8
Harvest acidity					
Fruit weight (g)	250.37	182.42	173.32	175.8	170.6
Remarks, harvest	lacking in sugar, acid	too acid		lacking in sugar, too acid, crisp, juicy, shape and size variable, not of much interest	lacking in sugar, very acid
Pressure 1 month (kg)					5.7
Brix 1 month					11.5
Remarks, 1 month					

Name:	**GA 001**				
Code:	T81				
Year planted:	1998				
Surface colour:	+90% red/pink-streaked				
Ground colour:	green				
Shape:	round				
Colour of flesh:	white to greenish				
Texture of flesh:	crisp, somewhat soft				
Flavour:	acid, sweet, bland, fair				
YEAR	2000	2001	2002	2003	2004
Date harvested	Oct. 17	Oct. 4	Oct. 15.	Oct. 14	28 sept.
Ripeness index	5	6	5	5	3
Harvest pressure (kg)	6.1	6.8	6.7	5.4	6.8
Harvest Brix	12	11.4	12.6	12.5	10.7
Harvest acidity		0.47	.	.	.
Fruit weight (g)	157.98	145.42	143.06	148.32	149.7
Remarks, harvest	acid, not very sweet, bland, lacking in firmness, McI type, size uneven, very susceptible to scab	McI type, not of much interest, flavour, size and shape variable	acid, sweet, crisp, later McI type, not much pressure, too acid	fruit very colourful, unpleasant taste, not much pressure	unpleasant, shape variable, not much pressure, uninteresting
Pressure 1 month (kg)	5.6	4.6	5		6.4
Brix 1 month	11.7	12.5	12.9		11.6
Remarks, 1 month			soft, old apple taste, unpleasant		unpleasant, not much pressure

Name:	**McI Summerland (control)** (no photo)				
Code:	T83				
Year planted:	1997				
Surface colour:	50-90% red blush				
Ground colour:	green				
Shape:	round				
Colour of flesh:	white				
Texture of flesh:	juicy, crisp				
Flavour:	acid, sweet, good				
YEAR	2000	2001	2002	2003	2004
Date harvested	Sept. 20	Sept. 20	Oct. 02	Sept. 24	Sept. 20
Ripeness index	6	6	6	6	5
Harvest pressure (kg)	7.0	7.1	6.8	6.8	6.8
Harvest Brix	12.9	13.3	12.8	12.1	11.5
Harvest acidity	.	.	.		
Fruit weight (g)	188.41	149.09	161.70	153.88	176.5
Remarks, harvest					

Name:	**MN 1403**				
Code:	T76				
Year planted:	1998				
Surface colour:	-50% red blush				
Ground colour:	yellow				
Shape:	round				
Colour of flesh:	cream				
Texture of flesh:	crisp				
Flavour:	sweet, aromatic, excellent				
YEAR	2000	2001	2002	2003	2004
Date harvested	Sept. 25	20 sept.	Sept. 24	Sept. 17	1 sept.
Ripeness index	7	6	6	6	4
Harvest pressure (kg)	6.9	7.3	8.2	6.6	9.1
Harvest Brix	12.3	12.6	15.8	13.3	12.5
Harvest acidity		0.47	.	.	
Fruit weight (g)	242.55	152.93	126.97	175.08	177.2
Remarks, harvest	pear aroma, attractive	banana flavour, hardly acid at all		ripeness uneven, heart watery, sweet, banana flavour when very ripe (deep yellow), acid otherwise.	ripeness uneven, sweet, not very good
Pressure 1 month (kg)		7.5		7.2	8.6
Brix 1 month		12.8		13.5	12.4
Remarks, 1 month		very sweet		sweet, crisp	
Pressure 2 months (kg)		5.6		6	
Brix 2 months		12.9		14	
Remarks, 2 months		lacking in firmness, sweet		unpleasant taste	

Name:	**MN 1788**				
Code:	T77				
Year planted:	1998				
Surface colour:	+90% red-streaked				
Ground colour:	green				
Shape:	variable, round to conic				
Colour of flesh:	yellow				
Texture of flesh:	juicy, crisp				
Flavour:	Acid				
YEAR	2000	2001	2002	2003	2004
Date harvested	Sept. 13	Sept. 14	Sept. 10	Sept. 16	Sept. 10
Ripeness index	4	5	.	4	4
Harvest pressure (kg)	7.2	7.4	7.7	7.3	7.5
Harvest Brix	10.9	11.1	11.6	10.8	9.6
Harvest acidity	0.95	0.79			
Fruit weight (g)	289.66	226.88	192.48	252.8	189.7
Remarks, harvest	very acid, not very sweet, unsweetened pineapple flavour, scald on 60% of fruits	ripeness uneven	soggy breakdown, not very sweet	not very sweet, ripeness uneven, bland, size variable, fruit generally attractive	fruit attractive, bland, acid, not much sugar
Pressure 1 month (kg)	7	7.3		6.3	7.5
Brix 1 month	11.2	11.4		11	9.9
Remarks, 1 month	crisp. fruity	crisp, sweet, juicy, attractive fruit, somewhat large in size	crisp		
Pressure 2 months (kg)		4.7		no tests, half the fruits rotten	
Brix 2 months		11.8			
Remarks, 2 months		not much pressure, bland			

Name:	**MN 1797**				
Code:	T78				
Year planted:	1998				
Surface colour:	50-90% red blush				
Ground colour:	green				
Shape:	round				
Colour of flesh:	white				
Texture of flesh:	juicy, crisp				
Flavour:	acid, sweet, fair				
YEAR	2000	2001	2002	2003	2004
Date harvested	Sept. 13	Sept. 13	Sept. 16	Sept. 19	Sept. 7
Ripeness index	7	7	6	7	7
Harvest pressure (kg)	8.4	8.6	9.3	8.1	8.8
Harvest Brix	13.9	13.2	15.2	12.6	12.3
Harvest acidity	0.9	0.62	.	.	
Fruit weight (g)	161.6	163.24	125.95	170.76	171.6
Remarks, harvest	sweet, hardly acid at all, pickled gherkin taste	sweet, Lobo type	soggy breakdown	soggy breakdown	crisp, lacking in colour, soggy breakdown
Pressure 1 month (kg)	8.7	7.9		8	9
Brix 1 month	13.6	12.8		13	13.4
Remarks, 1 month	sweet, firm			crisp, sweet, not of much interest	
Pressure 2 months (kg)		5.5			7.7
Brix 2 months		13.1			12.5
Remarks, 2 months		crisp, unpleasant taste			

Name:	**NJ 75**				
Code:	T75				
Year planted:	1998				
Surface colour:	-50% pink blush				
Ground colour:	yellow				
Shape:	conic				
Colour of flesh:	white				
Texture of flesh:	juicy, crisp				
Flavour:	sweet, aromatic, fair				
YEAR	2000	2001	2002	2003	2004
Date harvested	Sept. 13	Sept. 13	Sept. 16	Sept. 17	Sept. 10
Ripeness index	6	6	6	7	5
Harvest pressure (kg)	6.7	6.8	7.8	6.3	8.2
Harvest Brix	12.3	13.1	14.7	13.9	13
Harvest acidity	0.63	0.43	.	.	
Fruit weight (g)	171.26	138.06	133.3	163.76	160.4
Remarks, harvest	distinctive banana aroma, slightly lacking in acidity, fruity, sweet	sweet, not acid, skin a little thick		aromatic, sweet, skin a little thick, slightly acid	ripeness uneven, sweet, light aroma, dry
Pressure 1 month				5.7	8.2
Brix 1 month				14.1	14.7
Remarks, 1 month				soft, bland, sweet, not good	

Name:	**Regent**				
Code:	T80				
Year planted:	1998				
Surface colour:	50-90% red-streaked				
Ground colour:	green				
Shape:	ovate				
Colour of flesh:	cream				
Texture of flesh:	juicy, crisp				
Flavour:	acid, sweet, fair				
YEAR	2000	2001	2002	2003	2004
Date harvested	Sept. 28	Sept. 28	Oct. 8	Oct. 14	Oct. 4
Ripeness index	4	6	5	7	7
Harvest pressure (kg)	7.2	8	6.7	7	7.6
Harvest Brix	11.4	13.3	12.5	13	10.7
Harvest acidity	0.66	.	.	.	.
Fruit weight (g)	205.6	193.12	152.26	201.28	146.6
Remarks, harvest	soggy breakdown	not very sweet, taste unpleasant		soggy breakdown, sweet, juicy, lacking in aroma	sweet, watery, juicy, not acid, not of much interest
Pressure 1 month (kg)	7.3		6.9	7.2	7.6
Brix 1 month	11.7		12.9	12.3	10.8
Remarks, 1 month	juicy, bland, acid		sweet, skin thick, pressure moderate, light aroma	skin thick, flavour fair	juicy, crisp, no aroma, lacking in sugar

Name:	**Stark Summered Treat** (no photo)				
Code:	T74				
Year planted:	1998				
Surface colour:	-90% red blush				
Ground colour:	green				
Shape:	round				
Colour of flesh:	cream				
Texture of flesh:	juicy, crisp				
Flavour:	sweet, fair				
YEAR	2000	2001	2002	2003	2004
Date harvested	Aug. 22	Aug. 07	Aug. 20	Aug. 26	Aug. 31
Ripeness index	.	5	.	3	
Harvest pressure (kg)	.	6.04	7	5	
Harvest Brix	.	12.1	12.6	11.6	
Harvest acidity	.				
Fruit weight (g)	243.67	171.56	153.02	226.1	
Remarks, harvest	fruit good, should be harvested earlier; seriously overripe		soggy breakdown, ripeness uneven	soggy breakdown, lacking in sugar, ripeness uneven, colouring excellent	no tests, all fruits had fallen

Name:	**Zestar!**				
Code:	T79				
Year planted:	1998				
Surface colour:	50-90% red blush				
Ground colour:	yellow				
Shape:	round				
Colour of flesh:	cream				
Texture of flesh:	juicy, crisp				
Flavour:	acid, sweet, good				
YEAR	2000	2001	2002	2003	2004
Date harvested	Aug. 31	Aug. 30	Aug. 26	Aug. 26	Aug. 31
Ripeness index	5	4	.	3	5
Harvest pressure (kg)	6.9	6.3	7.7	7.1	6.1
Harvest Brix	13	14.3	15.3	11.3	14
Harvest acidity	.	.	.	.	.
Fruit weight (kg)	173.16	215.7	140.66	170.44	178.6
Remarks, harvest	flavour good fruit attractive, crisp	soggy breakdown	colouring and flavour fair, crisp, juicy	flavour good, crisp, acid/sweet, lacking in colour, firmness good	sweet, attractive fruit, colouring excellent
Pressure 1 month (kg)		6.8	.	2 weeks: 6.4	6
Brix 1 month		14.1	.	13.5	14
Remarks, 1 month		sweet, crisp		flavour good, acid, crisp, sweet, skin thick	unpleasant; old apple taste
Pressure 2 months (kg)		4.8	6.2	5.5	
Brix 2 months		14.4	15.7	13	
Remarks, 2 months		no pressure, very sweet	sweet, not much pressure, candy flavour	sweet, flavour good, not much pressure	

1999-2005 trial

Name:	**8B-14-56**				
Code:	T89				
Year planted:	1999				
Surface colour:	+90% red blush				
Ground colour:	yellow				
Shape:	conic				
Colour of flesh:	yellow				
Texture of flesh:	juicy, crisp				
Flavour:	sweet, aromatic, good				
YEAR	2001	2002	2003	2004	2005
Date harvested	Oct. 9	Oct. 18	Oct. 14	Oct. 4	Oct. 12
Ripeness index	5	6	3	3	4
Harvest pressure (kg)	6.8	6	6.2	6.6	6
Harvest Brix	15.1	15	14.7	12	14.6
Harvest acidity	.		.	.	
Fruit weight (g)	197.6	228.26	170.88	198.4	177.38
Remarks, harvest	soggy breakdown, aroma strong and persistent, fruity	heart watery, some fruits with pronounced flavour, other bland	sweet, aromatic, moderate firmness, good fruit	very sweet, not very acid, juicy, no aroma, overripe, lacking in firmness	soggy breakdown
Pressure 1 month (kg)			5.4	6.4	5
Brix 1 month			14.5	12.1	15
Remarks, 1 month			sweet, skin thick, soft		sweet, lacking in firmness

Name:	**8S-27-02**				
Code:	T84				
Year planted:	1999				
Surface colour:	+90% red blush				
Ground colour:	pale green				
Shape:	conic				
Colour of flesh:	cream				
Texture of flesh:	crisp, sometimes dry				
Flavour:	sweet, acid, fair to good				
YEAR	2001	2002	2003	2004	2005
Date harvested	Oct. 11	Oct. 18	Oct. 14	Oct. 14	Oct. 20
Ripeness index	5	3	3	3	6
Harvest pressure (kg)	10.7	9.8	9.6	8.6	8.2
Harvest Brix	13.5	15.7	14.3	11.7	13.6
Harvest acidity	0.52	.	.		
Fruit weight (g)	114.84	144.62	116.84	128	120.16
Remarks, harvest	stalk fleshy, not very acid	skin thick, texture granular, flavour pronounced	sweet, acid, crisp	acid, sweet, no aroma, crisp	crisp, lacking in juice, sweet, tannin, no aroma, hint of bitterness
Pressure 1 month (kg)	7.6	10.6		8.4	
Brix 1 month	13.3	15.9		12.1	
Remarks, 1 month	crisp, not very flavourful	very firm and sweet		not very flavourful, crisp, sweet	
Pressure 2 months (kg)	7.1				
Brix 2 months	13.8				
Remarks, 2 months					

Name:	**8S-29-18**				
Code:	T86				
Year planted:	1999				
Surface colour:	+90% pink/red blush				
Ground colour:	green				
Shape:	attenuate toward the calyx				
Colour of flesh:	cream				
Texture of flesh:	juicy, crisp				
Flavour:	sweet, good				
YEAR	2001	2002	2003	2004	2005
Date harvested	Oct. 9	Oct. 18	Oct. 14	Oct. 14	Oct. 20
Ripeness index	4	4	4	5	5
Harvest pressure (kg)	8.8	8.2	8.8	8.1	7.8
Harvest Brix	12.9	14.4	13.1	13	13.9
Harvest acidity	0.32				
Fruit weight (g)	129.87	155.92	133.64	153.1	145.64
Remarks, harvest	Red Delicious type, stalk very fleshy, skin somewhat thick	not very acid, sweet, Red Delicious flavour	unpleasant taste, sweet, not very acid, bland	no aroma and no acidity, sweet, bland, crisp	crisp, juicy, lacking in flavour, skin thick
Pressure 1 month (kg)	9.1	7.8		7.6	7.3
Brix 1 month	13.6	14.6		12.7	14.5
Remarks, 1 month	crisp, sweet, flavour fair	crisp, juicy, sweet, flavour fair		sweet, juicy, bland	very sweet, not much aroma, flavour good, crisp

Name:	**8S-31-56**				
Code:	T87				
Year planted:	1999				
Surface colour:	=90% red blush				
Ground colour:	yellow				
Shape:	ovate				
Colour of flesh:	yellow				
Texture of flesh:	juicy, crisp				
Flavour:	sweet, bland, fair				
YEAR	2001	2002	2003	2004	2005
Date harvested	Oct. 9	Oct. 18	Oct. 14	Oct. 14	Oct. 20
Ripeness index	.	4	4	3	5
Harvest pressure (kg)	.	7	6.6	6.6	6.9
Harvest Brix	.	13.8	12.5	11.5	13.8
Harvest acidity	.	.	.	.	.
Fruit weight (g)	237	216.21	184.84	191.3	185.8
Remarks, harvest	only 2 fruits; no tests	size variable, shape variable, sweet, not very acid, lacking in firmness	sweet, bland, juicy, crisp	no aroma, no acidity, sweet, bland	bland, no acidity, texture somewhat dry, lacking in firmness
Pressure 1 month (kg)		7	6.8	6.6	6.7
Brix 1 month		14.6	13	11.8	14.3
Remarks, 1 month		sweet, acid, not very flavourful	bland, somewhat dry		sweet, unpleasant taste

Name:	**Aurora Golden Gala**				
Code:	T90				
Year planted:	1999				
Surface colour:	-50% pink blush				
Ground colour:	yellow				
Shape:	conic to ovate				
Colour of flesh:	yellow				
Texture of flesh:	juicy, crisp				
Flavour:	sweet, aromatic, good				
YEAR	2001	2002	2003	2004	2005
Date harvested	Oct. 9	Oct. 9	Oct. 14	Oct. 5	Oct. 4
Ripeness index	6	4	7	5	4
Harvest pressure (kg)	7.4	7.6	7.2	7	7.4
Harvest Brix	13.8	14.2	14	13	14
Harvest acidity	0.26	.	.	.	.
Fruit weight (g)	148.98	134.1	126.44	148.6	135.12
Remarks, harvest	not very acid, juicy, sweet, crisp, Golden type	russeting, sweet, juicy, crisp, slightly spicy	sweet, aromatic, crisp	sweet, crisp, juicy, not very acid	
Pressure 1 month (kg)	6.9	8.1		7.8	8.1
Brix 1 month	14.2	14.2		12.6	14.6
Remarks, 1 month				not very acid, bland	
Pressure 2 months (kg)	6.9				
Brix 2 months	14.7				
Remarks, 2 months	texture enjoyable, fruit good, very crisp, juicy, spicy, sweet				

Name:	**Chinook**				
Code:	T85				
Year planted:	1999				
Surface colour:	+90% deep pink blush				
Ground colour:	yellow				
Shape:	conic				
Colour of flesh:	yellow				
Texture of flesh:	crisp				
Flavour:	sweet, fair				
YEAR	2001	2002	2003	2004	2005
Date harvested	Oct. 11	Oct. 17	Oct. 14	Oct. 14	Oct 20
Ripeness index	3	3	4	4	5
Harvest pressure (kg)	9.1	9.7	10.2	9.2	8.3
Harvest Brix	12.2	13.6	12.9	11.9	13.4
Harvest acidity	0.4				
Fruit weight (g)	84.8	99.5	110.84	131.06	94.84
Remarks, harvest	skin thick	skin thick	sweet, not very flavourful	no aroma, not very flavourful, sweet, crisp	acid, sweet
Pressure 1 month (kg)	10.5		9.7		
Brix 1 month	14.4		13.6		
Remarks, 1 month	crisp, not much flavour, sweet		crisp, sweet, texture somewhat dry		
Pressure 2 months (kg)	10.4				
Brix 2 months	15.3				
Remarks, 2 months	sweet, crisp				

Name:	**Gala Scarlet**				
Code:	T95				
Year planted:	1999				
Surface colour:	+90% orange-red streaked				
Ground colour:	yellow				
Shape:	conic				
Colour of flesh:	yellow				
Texture of flesh:	crisp				
Flavour:	sweet, aromatic, good				
YEAR	2001	2002	2003	2004	2005
Date harvested	Sept. 28	Sept. 24	Sept. 24	Sept. 20	Sept. 19
Ripeness index	7	3	6	3	4
Harvest pressure (kg)	8.6	9.6	9.5	9.1	9.4
Harvest Brix	13.5	13.1	13.3	11.8	12.5
Harvest acidity	0.4	.	.	.	.
Fruit weight (g)	130.98	129.12	138.08	161.02	132.3
Remarks, harvest	banana flavour		several fruits misshapen	crisp, juicy, lacking in sugar, aromatic, russeting	bland, skin thick
Pressure 1 month (kg)	8.5	9.2	9.4	9.3	8.9
Brix 1 month	13.8	13.4	13.4	12.1	13.4
Remarks, 1 month	crisp, juicy, flavour fair to good		firm, sweet, flavour good	sweet, crisp	firm, crisp, flavour good, very sweet
Pressure 2 months (kg)	6.3		8.4		
Brix 2 months	13.9		12.3		
Remarks, 2 months	sweet, crisp		good, crisp, sweet		

Name:	**Jonagold Rubinstar** (no photo)				
Code:	T96				
Year planted:	1999				
Surface colour:	50-90% orange-red streaked				
Ground colour:	yellowish green				
Shape:	round				
Colour of flesh:	yellow				
Texture of flesh:	juicy, crisp				
Flavour:	acid, sweet, aromatic, good				
YEAR	2001	2002	2003	2004	2005
Date harvested	Oct. 3	Oct. 8	Oct. 9	Oct. 5	4 oct.
Ripeness index	7	6	6	6	7
Harvest pressure(kg)	8	7.2	7.1	7.1	7.6
Harvest Brix	13	14.6	12.9	12.6	13.5
Harvest acidity	0.42	.	.	.	.
Fruit weight (g)	181.14	243.36	176.76	230.1	181
Remarks, harvest		hint of bitterness	hint of bitterness, skin somewhat thick, acid/sweet balance, juicy, flavour good	hint of bitterness, moderately acid, crisp, juicy, sweet, colourful	
Pressure 1 month (kg)	5.3	6.4		7.1	6.2
Brix 1 month	13	16		13	13.5
Remarks, 1 month		sweet, juicy, little/no aroma, pressure moderate to low		crisp, juicy, slightly acid, lacking in sugar	

Name:	**NJ 114** (no photo)				
Code:	T 93				
Year planted:	1999				
Surface colour:	-50% pink blush				
Ground colour:	yellow				
Shape:	round				
Colour of flesh:	cream				
Texture of flesh:	juicy, crisp				
Flavour:	acid, bland, fair				
YEAR	2001	2002	2003	2004	2005
Date harvested	Aug. 21	Aug. 26	Aug. 26	Aug. 31	Aug. 23
Ripeness index	8	.	7	.	7
Harvest pressure (kg)	6.2	5.9	5.8	.	5.4
Harvest Brix	11	11.6	10.8	.	11.5
Harvest acidity	.	.	.	.	
Fruit weight (g)	137.28	116.8	110.55	.	106.96
Remarks, harvest	crisp, sweet, flavour fair		soggy breakdown, lacking in sugar, unpleasant taste, not of much interest, fruits falling	all fruits had fallen, no tests	
Pressure 1 month (kg)					
Brix 1 month					
Remarks, 1 month					

Name:	**Pinova**				
Code:	T94				
Year planted	1999				
Surface colour:	+90% orange-red blush/streaked				
Ground colour:	yellow				
Shape:	round				
Colour of flesh:	yellow				
Texture of flesh:	juicy, crisp				
Flavour:	sweet, aromatic, good				
YEAR	2001	2002	2003	2004	2005
Date harvested	Oct. 11	Oct. 17	Oct. 9	Oct. 14	Oct. 6
Ripeness index	5	6	5	7	4
Harvest pressure (kg)	7.3	7.6	7.9	7.6	7.6
Harvest Brix	14.8	16.2	13.9	12.9	14.3
Harvest acidity	0.48	.	.	.	0.77
Fruit weight (g)	176.26	182.94	155.8	158.1	157.4
Remarks, harvest	fruit very good	skin thick, sweet, spicy, dry	sweet, spicy, not very acid	sweet, slightly acid, skin thick, lacking in aroma	spicy, aromatic, sweet, texture slightly dry, skin thick
Pressure 1 month (kg)	7.4	8		6.9	7.2
Brix 1 month	15.1	16.1		12.5	15.3
Remarks, 1 month	spicy, sweet, crisp	texture a little spongy, sweet, spicy		sweet, flavour fair, crisp, juicy	
Pressure 2 months (kg)	6.7				
Brix 2 months	15.6				
Remarks, 2 months	spicy, sweet, crisp				

Name:	**Silken**				
Code:	T88				
Year planted:	1999				
Surface colour:	50% pink blush				
Ground colour:	pale yellow				
Shape:	conic				
Colour of flesh:	cream				
Texture of flesh:	juicy, crisp				
Flavour:	sweet, good				
YEAR	2001	2002	2003	2004	2005
Date harvested	Sept. 20	Oct. 1	Sept. 24	Sept. 20	Sept. 19
Ripeness index	.	6	6	7	4
Harvest pressure (kg)	7.6	7.1	6.9	6.9	7
Harvest Brix	13.3	14.3	14.1	13.5	13.3
Harvest acidity	0.35				
Fruit weight (g)	184.92	149	134.84	141.4	126.32
Remarks, harvest	no acidity, good, sweet, crisp	good, sweet, crisp	not very flavourful, scab on fruit, sooty blotch	crisp, juicy, sweet, very good	sweet, crisp, juicy, very good
Pressure 1 month (kg)	5.3	6.5		7.4	6.8
Brix 1 month	13.4	15		12.7	13.5
Remarks, 1 month	aftertaste, sweet, crisp, not acid	very sweet, crisp, not acid	old apple aftertaste		juicy, good
Pressure 2 months (kg)	4.6				
Brix 2 months	14.6				
Remarks, 2 months	storage 5 weeks				

Name:	**Spa 343**				
Code:	T92				
Year planted:	1999				
Surface colour:	+90% pinkish-orange blush/streaked, russeted over entire surface				
Ground colour:	yellow				
Shape:	round oblate				
Colour of flesh:	cream				
Texture of flesh:	dry, firm, granular				
Flavour:	acid, very sweet, spicy, good				
YEAR	2001	2002	2003	2004	2005
Date harvested	Oct. 9	Oct. 18	Oct. 14	Oct. 14	Oct. 12
Ripeness index	3	5	4	4	5
Harvest pressure (kg)	10	9.3	10.7	9.7	9.3
Harvest Brix	18.2	19	18.7	17.5	17
Harvest acidity	0.76	.	.	.	
Fruit weight (g)	121	144.28	103.35	132.2	109.7
Remarks, harvest	very good, russet type	very good, sweet, spicy	sweet, spicy,	sweet	
Pressure 1 month (kg)	10.2	9.8	10.5	9.4	8.9
Brix 1 month	19.6	17.8	20	18.5	18.8
Remarks, 1 month		very sweet, granular	granular, flavour pronounced	hint of bitterness, very sweet, firm	skin thick, granular, firm
Pressure 2 months (kg)	9.2				
Brix 2 months	19.1				
Remarks, 2 months	very good, texture dry, crisp, very sweet				

Appendix 4. Fruit Data Sheets - Cultivar Trials 1997-2003 *(photos M. Audette, AAC)*

Emerald Spire

Scarlet Spire

Ottawa-654 (no photo)

Ottawa 662

Ottawa 665

Ottawa 6412

Ottawa 6413

Appendix 5. Fruit Data Sheets - Cultivar Trials 1998-2004 *(photos M. Audette, AAC)*

Fayette

GA001

McI Summerland (Control) (no photo)

MN1403

MN1788

MN1797

NJ75

Regent

Stark Summered Treat (no photo)

Zestar!

Appendix 6. Fruit Data Sheets - Cultivar Trials 1999-2005 *(photos M. Audette, AAC)*

8B-14-56

8S-27-02

8S-29-18

8S-31-56

Aurora Golden Gala

Chinook

Gala Scarlet

Jonagold Rubinstar (no photo)

NJ114 (no photo)

Pinova

Silken

Spa 343

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Fédération des producteurs de pommes du Québec
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RECUPOM

(Réseau d'essais de cultivars et de porte-greffes de pommiers 2009)

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