



# ANNUAL REPORT TO NC-140

## Massachusetts Agricultural Experiment Station

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### PROGRESS & PRINCIPAL ACCOMPLISHMENTS

Table 1. Trunk cross-sectional area, tree height, canopy spread, and suckering in 2006 of Gala trees on various rootstocks in the Massachusetts planting of the 1998 NC-140 Apple Rootstock Trial. All values are least-squares means, adjusted for missing subclasses.<sup>z</sup>

Rootstock	Trunk cross-sectional area (cm <sup>2</sup> )	Tree height (m)	Canopy spread (m)	Root suckers (no./tree, 1998-2006)
G.16	33.7 a	2.6 a	2.8 a	3.3 a
M.9	23.0 b	2.4 a	2.4 b	1.4 a
M.9 EMLA	20.8 b	2.3 a	2.4 b	2.2 a

<sup>z</sup> Means were separated within columns by Tukey's HSD ( $P = 0.05$ ).

#### 1998 NC-140 Apple

As part of the 1998 NC-140 Apple Rootstock Trial, a planting of Gala on three rootstocks was established at the University of Massachusetts Cold Spring Orchard Research & Education Center in 1998. These trees are on a non-irrigated site, and have not performed as well as desired in previous years, but they yielded well in 2006 (average of 19 kg per tree) with good fruit size (averaging 185 g). The experiment was a randomized-complete-block design with ten replications. Means from 2006 (9<sup>th</sup> growing season) are included in Tables 1 and 2.

Rootstock significantly affected

Table 2. Yield, yield efficiency, and fruit weight in 2006 of Gala trees on various rootstocks in the Massachusetts planting of the 1998 NC-140 Apple Rootstock Trial. All values are least-squares means, adjusted for missing subclasses.<sup>z</sup>

Rootstock	Yield per tree (kg)		Yield efficiency (kg/cm <sup>2</sup> TCA)		Fruit weight (g)	
	2006	Cumulative (1999-2006)	2006	Cumulative (1999-2006)	2006	Average (1999-2006)
G.16	30.7 a	126 a	0.92 a	3.73 a	171 a	135 b
M.9	15.6 b	87 b	0.67 b	3.77 a	189 a	164 a
M.9 EMLA	10.9 b	82 b	0.58 b	3.94 a	196 a	160 a

<sup>z</sup> Means were separated within columns by Tukey's HSD ( $P = 0.05$ ).

trunk cross-sectional area (TCA), with trees on G.16 significantly larger than those on M.9 or M.9 EMLA (Table 1). Tree height did not differ among trees on the three rootstocks, but canopy spread was greater for trees on G.16 than those on either M.9 strain. Cumulative (1998-2006) root suckering was not affected by rootstock.

Yields per tree

Table 3. Trunk cross-sectional area, suckering, yield, yield efficiency, and fruit weight in 2006 of McIntosh trees on several rootstocks in the Massachusetts planting of the 1999 NC-140 Dwarf Apple Rootstock Trial. All values are least-squares means, adjusted for missing subclasses and for crop load in the case of 2006 fruit weight.<sup>z</sup>

Rootstock	Trunk cross-sectional area (cm <sup>2</sup> )	Root suckers (no./tree, 1999-2006)	Yield per tree (kg)		Yield efficiency (kg/cm <sup>2</sup> TCA)		Fruit weight (g)	
			2006	Cumulative (2001-06)	2006	Cumulative (2001-06)	2006	Average (2001-06)
G.41	44.2 bcd	2.0 bc	45.6 abcd	139 bcd	1.1 a	3.2 ab	169 a	163 ab
CG.4013	72.8 a	7.7 a	68.6 a	215 a	1.0 a	3.0 ab	160 a	159 abc
CG.5179	49.7 bc	5.7 ab	60.6 ab	186 ab	1.2 a	3.7 ab	162 a	157 abc
G.202	56.4 ab	1.3 bc	57.7 abc	171 abc	1.1 a	3.2 ab	166 a	159 abc
G.16N	37.1 bcd	0.0 c	32.1 d	98 d	0.9 a	2.7 b	171 a	165 ab
G.16T	36.2 bcd	1.5 bc	33.8 cd	111 cd	0.9 a	3.1 ab	151 a	156 abc
M.26 EMLA	41.5 bcd	0.0 c	42.2 bcd	107 cd	1.1 a	2.6 b	164 a	160 ab
M.9 NAKBT337	25.5 d	2.6 abc	30.1 d	81 d	1.1 a	3.2 ab	177 a	171 a
Supporter 1	26.8 d	0.0 c	31.4 d	105 d	1.2 a	3.9 ab	177 a	161 ab
Supporter 2	30.2 d	1.6 bc	38.6 bcd	121 cd	1.3 a	4.1 a	155 a	142 c
Supporter 3	34.5 cd	0.5 c	40.5 bcd	132 bcd	1.2 a	3.9 ab	164 a	153 bc

<sup>z</sup> Means were separated within columns by Tukey's HSD ( $P = 0.05$ ).

in 2006 and cumulatively (1999-2006) were greater from trees on G.16 than from trees on either M.9 strain (Table 2). In 2006, G.16 resulted in the most yield-efficient trees (Table 2), but cumulatively (1999-2006), trees on the three rootstocks did not differ significantly. In 2006, rootstock did not affect fruit size, but on average (1999-2006), G.16 resulted in smaller fruit size than did M.9 or M.9 EMLA.

### 1999 NC-140 Dwarf Apple

As part of the 1999 NC-140 Dwarf Apple Rootstock Trial, a planting of McIntosh on 11 rootstocks was established at the University of Massachusetts Cold Spring Orchard Research & Education Center in 1999. Trees in this trial have performed well (average 2006 yield of 40 kg per tree with 165g average fruit size). The planting included six replications in a randomized-complete-block design. Means from 2006 (8<sup>th</sup> growing season) are included in Table 3.

At the end of the 2006 season, largest trees were on CG.4013, and the smallest were on M.9 NAKBT337, Supporter 1, and Supporter 2. Trees on G.16 were slightly, but not significantly, smaller than those on M.26 EMLA, and trees on G.41 were slightly, but not significantly, larger than those on M.26 EMLA. Trees on G.202 were among the largest, intermediate between those on CG.4013 and those on CG.5179. Cumulative suckering (1999-2006) was greatest from CG.4013 and CG.5179 and least from G.16N, M.26 EMLA, Supporter 1, and Supporter 3.

CG.4013, CG.5179, and G.202 resulted in the greatest yields per tree in 2006 and cumulatively (2001-06), while M.9 NAKBT337, Supporter 1, and G.16N resulted in the lowest. In

2006, rootstock did not affect yield efficiency, but cumulatively (2001-06), the trees on Supporter 2 were significantly more yield efficient than those on G.16N or M.26 EMLA. All other combinations had intermediate efficiency. Rootstock did not affect fruit size in 2006, but on average (2001-06), fruit were from trees on M.9 NAKBT337 were larger than those from trees on Supporter 2 and Supporter 3, with all other rootstocks resulting

Table 4. Trunk cross-sectional area, trunk lean, and suckering in 2006 of McIntosh trees on several rootstocks in the Massachusetts planting of the 1999 NC-140 Semidwarf Apple Rootstock Trial. All values are least-squares means, adjusted for missing subclasses.<sup>z</sup>

Rootstock	Trunk cross-sectional area (cm <sup>2</sup> )	Trunk lean (° from vertical)	Root suckers (no./tree, 2002-06)
CG.4814	30.5 b	3 a	20.2 a
CG.7707	39.9 b	13 a	5.0 b
G.30N	65.8 a	8 a	8.3 b
M.26 EMLA	36.4 b	13 a	3.0 b
M.7 EMLA	77.0 a	15 a	53.7 a
Supporter 4	66.8 a	18 a	5.3 b

<sup>z</sup> Means were separated within columns by Tukey's HSD ( $P = 0.05$ ).

in intermediate average fruit size.

### 1999 NC-140 Semidwarf Apple

As part of the 1999 NC-140 Semidwarf Apple Rootstock Trial, a planting of McIntosh on six rootstocks was established at the University of Massachusetts Cold Spring Orchard Research & Education Center in 1999. Trees in this trial have performed reasonable well (average 2006 yield of 57 kg

per tree with 173g average fruit size); however, leaning has been an issue with some. The planting included six replications in a randomized-complete-block design. Means from 2006 (8<sup>th</sup> growing season) are included in Tables 4 and 5.

At the end of the 2006 season, largest trees were on M.7 EMLA, Supporter 4, and G.30N, all significantly larger than those on M.26 EMLA, CG.4814, and CG.7707 (Table 4). Degrees of lean from vertical did not differ significantly but was numerically greatest for trees on M.7 EMLA and Supporter 4 and least for trees on CG.4814 and G.30N. Greatest cumulative (1999-2006) root suckering was observed from trees on M.7 EMLA and CG.4814.

G.30N resulted in the most yield per tree in 2006 and cumulatively (2001-06), while M.26 EMLA resulted in the least (Table 5). Cumulatively, trees on G.30N yielded more than all other combinations. Trees on CG.4814 were the most yield efficient in 2006 and cumulatively (2004-06), and those on M.7 EMLA were the least efficient. Neither fruit weight in 2006 or on average (2001-06) was affected by rootstock.

### 2002 NC-140 Apple

As part of the 2002 NC-140 Apple Rootstock Trial, a planting of Gala on 11 rootstocks was established at the University of Massachusetts Cold Spring Orchard Re-

Table 5. Yield, yield efficiency, and fruit weight in 2006 of McIntosh trees on several rootstocks in the Massachusetts planting of the 1999 NC-140 Semidwarf Apple Rootstock Trial. All values are least-squares means, adjusted for missing subclasses.<sup>z</sup>

Rootstock	Yield per tree (kg)		Yield efficiency (kg/cm <sup>2</sup> TCA)		Fruit weight (g)	
	2006	Cumulative (2001-06)	2006	Cumulative (2001-06)	2006	Average (2001-06)
CG.4814	49.5 ab	141 bc	1.6 a	4.6 a	177 a	170 a
CG.7707	52.5 ab	142 bc	1.3 ab	3.6 b	175 a	171 a
G.30N	72.7 a	205 a	1.1 bc	3.1 bc	160 a	159 a
M.26 EMLA	42.4 b	100 c	1.2 bc	2.7 cd	178 a	170 a
M.7 EMLA	63.8 ab	142 bc	0.8 c	1.9 e	179 a	172 a
Supporter 4	63.1 ab	147 b	1.0 bc	2.3 de	168 a	165 a

<sup>z</sup> Means were separated within columns by Tukey's HSD ( $P = 0.05$ ).

search & Education Center in 2002. Trees are growing well in this irrigated block, but fruit set has been lighter than expected so far (average yields in 2006 of only 3 kg per tree with 157-g average fruit size). The planting included seven replications in a randomized-complete-block design. Means from 2006 (5<sup>th</sup> growing season) are included in Tables 6 and 7.

After the 2006 growing season, trees with the largest TCA were on PiAu51-4 and smallest were on B.9 (Europe) and B.9 (Tresco) (Table 6). Tree height followed a similar trend to TCA,

Table 6. Trunk cross-sectional area, tree height, canopy spread, suckering, and burr knot severity in 2006 of Gala trees on several rootstocks in the Massachusetts planting of the 2002 NC-140 Apple Rootstock Trial. All values are least-squares means, adjusted for missing subclasses.<sup>z</sup>

Rootstock	Trunk cross-sectional area (cm <sup>2</sup> )	Tree height (m)	Canopy spread (m)	Root suckers (no./tree, 2002-06)	Burr knots (% of circ.)
B.9 (Europe)	13.5 d	3.1 c	2.3 b	1.4 ab	1.4 b
B.9 (Tresco)	15.5 cd	3.3 c	2.4 b	0.0 b	1.1 b
M.26 EMLA	27.8 bc	3.5 bc	2.9 ab	2.1 ab	1.2 b
M.26 NAKB	33.1 b	3.8 abc	3.1 a	7.9 a	1.1 b
M.9 Burgmer 756	27.5 bc	4.0 ab	3.1 a	2.9 ab	2.1 b
M.9 Nic 29	23.2 bcd	3.6 bc	2.9 ab	1.1 ab	9.7 a
M.9 NAKBT337	23.3 bcd	3.7 bc	3.0 ab	0.0 b	1.9 b
P.14	33.8 b	3.9 ab	3.2 a	3.6 ab	0.4 b
PiAu51-11	30.1 b	3.9 ab	2.9 ab	5.0 ab	1.2 b
PiAu51-4	47.6 a	4.4 a	3.6 a	0.0 b	0.7 b
Supporter 4	25.2 bcd	3.6 bc	2.9 ab	0.0 b	0.1 b

<sup>z</sup> Means were separated within columns by Tukey's HSD ( $P = 0.05$ ).

Table 7. Yield, yield efficiency, and fruit weight in 2006 of Gala trees on several rootstocks in the Massachusetts planting of the 2002 NC-140 Apple Rootstock Trial. All values are least-squares means, adjusted for missing subclasses.<sup>z</sup>

Rootstock	Yield per tree (kg)		Yield efficiency (kg/cm <sup>2</sup> TCA)		Fruit weight (g)	
	2006	Cumulative (2004-06)	2006	Cumulative (2004-06)	2006	Average (2004-06)
B.9 (Europe)	5.8 ab	17 a	0.4 a	1.2 a	164 a	146 ab
B.9 (Treco)	5.8 ab	17 a	0.4 a	1.2 a	169 a	155 a
M.26 EMLA	2.8 abc	10 ab	0.1 b	0.4 b	163 a	132 ab
M.26 NAKB	4.1 abc	15 a	0.1 b	0.5 b	162 a	122 b
M.9 Burgmer 756	1.2 bc	9 ab	0.0 b	0.3 b	165 a	158 a
M.9 Nic 29	1.7 abc	11 ab	0.1 b	0.5 b	148 ab	158 a
M.9 NAKBT337	0.6 c	7 ab	0.0 b	0.3 b	176 a	155 a
P.14	4.5 abc	7 ab	0.1 b	0.2 b	150 ab	145 ab
PiAu51-11	1.5 abc	5 ab	0.0 b	0.2 b	155 a	136 ab
PiAu51-4	6.8 a	11 ab	0.1 b	0.2 b	177 a	156 a
Supporter 4	0.4 c	3 b	0.0 b	0.1 b	109 b	124 b

<sup>z</sup> Means were separated within columns by Tukey's HSD ( $P = 0.05$ ).

but canopy spread was greatest for trees on M.26 NAKB, M.9 Burgmer 756, P.14, and PiAu51-4 and smallest for trees on B.9 (Europe) and B.9 (Treco). Cumulative (2002-06) root suckering was significantly greater from M.26 NAKB than from B.9 (Treco), M.9 NAKBT337, PiAu51-4, or Supporter 4. The severity of burr knots was greatest on M.9 Nic 29, significantly greater than any other rootstock.

Fruit from trees on all other rootstocks averaged from 148 to 177 g, but those from trees on Supporter 4 were only 109 g. Average fruit size over the fruiting life of the planting (2004-06) was largest from trees on B.9 (Treco), M.9 Burgmer 756, M.9 Nic 29, M.9 NAKBT337, and PiAu51-4 and smallest from trees on M.26 NAKB and Supporter 4.

Yield in 2006 was greatest from trees on PiAu51-4, B.9 (Treco), and B.9 (Europe) least from trees on M.9 NAKBT337 and Supporter 4. Cumulatively (2004-06), yield was greatest from trees on B.9 (Treco), B.9 (Europe), and M.26 NAKB and least from trees on Supporter 4. Yield efficiency in 2006 and cumulatively (2004-06) was greatest for trees on B.9 (Treco) or B.9 (Europe), both significantly more efficient than all other rootstocks. Fruit size in 2006 was generally good for Gala, with the exception of fruit from trees on Supporter 4.

Table 8. Trunk cross-sectional area, canopy spread, cumulative suckering, yield, and fruit weight in 2006 of Redhaven trees on several rootstocks in the Massachusetts planting of the 2002 NC-140 Peach Rootstock Trial. All values are least-squares means, adjusted for missing subclasses.<sup>z</sup>

Rootstock	Trunk cross-sectional area (cm <sup>2</sup> )	Canopy spread (m)	Root suckers (no./tree, 2005-06)	Yield per tree (kg)		Yield efficiency (kg/cm <sup>2</sup> TCA)		Fruit weight (g)	
				2006	Cumulative (2005-06)	2006	Cumulative (2005-06)	2006	Average (2005-06)
Adesto 101	63.8 bc	3.9 c	4.0 ab	8.1 cd	8.8 bc	0.15 abc	0.16 bcd	139 a	145 a
Cadaman	107.2 a	4.9 a	0.0 c	24.0 ab	37.0 a	0.22 ab	0.34 ab	141 a	155 a
Lovell	101.2 a	4.7 ab	0.0 c	29.4 a	37.7 a	0.30 a	0.39 a	139 a	147 a
MRS 2/5	74.3 b	4.1 bc	4.9 a	17.1 bc	20.3 b	0.23 ab	0.27 abc	135 a	145 a
Penta	73.8 bc	4.2 abc	1.3 abc	9.8 cd	11.2 bc	0.14 abc	0.15 bcd	138 a	139 a
Pumiselect	45.5 cd	2.8 d	0.6 bc	0.3 d	1.5 c	0.01 c	0.03 d	---	148 a
VSV-1	29.8 d	2.8 d	0.4 c	3.2 d	4.4 c	0.10 bc	0.13 cd	131 a	149 a
VVA-1	45.8 cd	3.7 c	0.6 bc	6.1 cd	8.8 bc	0.14 abc	0.21 abcd	140 a	151 a

<sup>z</sup> Means were separated within columns by Tukey's HSD ( $P = 0.05$ ).

## 2002 NC-140 Peach

As part of the 2002 NC-140 Peach Rootstock Trial, a planting of Redhaven on eight rootstocks was established at Clarkdale Fruit Farm (Deerfield, Massachusetts) in 2002. The trees have grown reasonably well, but suffered a complete crop loss in 2004 (due to winter cold temperatures) and a partial crop loss in 2005 (due to spring frost). Average yield in 2006 was not ideal, but greater than 2005: 12 kg per tree with average fruit size was 138 g. The planting included eight replications in a randomized-complete-block design. Means from 2006 (5<sup>th</sup> growing season) are included in Table 8.

After the 2006 season, the largest trees (based both on TCA and canopy spread) were on Cadaman and Lovell, and the smallest were on VSV-1, Pumiselect, and VVA-1. Greatest cumulative root suckering (2002-06) was from MRS 2/5 and Adesto 101. To date, the greatest tree loss (50%) was of trees on Pumiselect. Penta loss was 25%, and MRS 2/5 and VVA-1 have both lost 12.5%. All losses appear to be due to low winter temperatures.

Yields per tree in 2006 and cumulatively (2005-06) were greatest from trees on Cadaman and Lovell and least from trees on Pumiselect and VSV-1. Likewise, trees on Cadaman and Lovell were the most yield efficient in 2006 and cumulatively (2005-06), and those on Pumiselect and VSV-1 were the least efficient. Fruit weight was not affected by rootstock.

## 2003 NC-140 Apple Physiology

As part of the 2003 NC-140 Apple Rootstock Physiology Trial, a planting of Gibson Golden Delicious on three rootstocks was established at the University of Massachusetts Cold Spring Orchard Research & Education Center in 2003. Trees in this trial grew very poorly during their first two seasons but grew well in 2005 and 2006. Fruiting was allowed in 2006, but crop load was adjusted to develop a similar range for all three rootstocks. Unfortunately, initial set was not great enough to allow the full range of desired fruit sets. The planting included ten trees of each rootstock in a completely random design. Means from

2006 (4<sup>th</sup> growing season) are included in Table 6 and Figure 1.

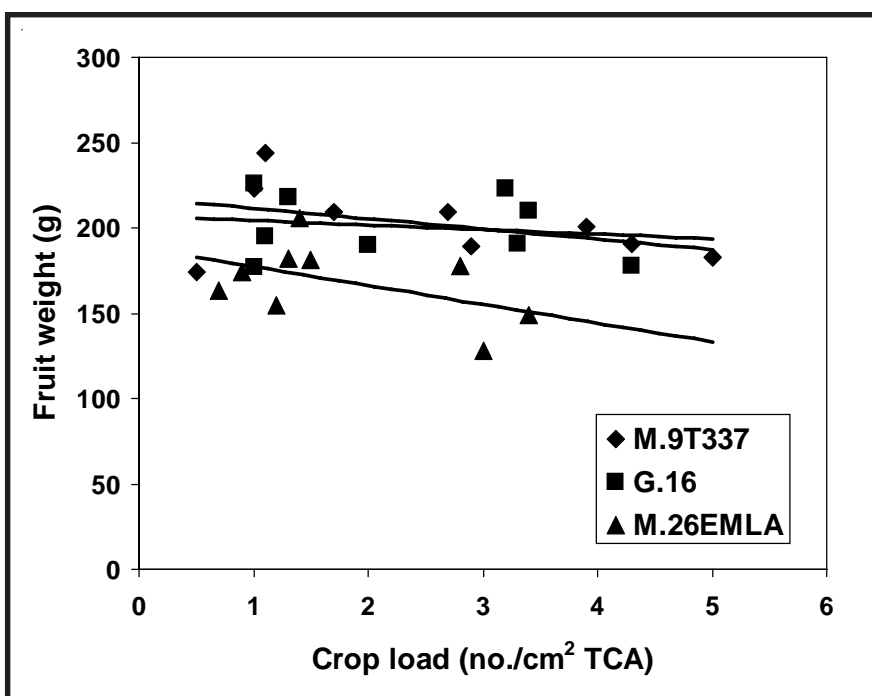
TCA's of trees on G.16 and M.26 EMLA were significantly greater than the TCA of trees on M.9 NAKBT337 (Table 1). Rootstock did not affect root suckering (2003-06) or yield per tree in 2006, but trees on M.9 were significantly more yield efficient than those on M.26 EMLA. Fruit weight was similar for trees on M.9 NAKBT337 and G.16, fruit from both being larger than those from trees on M.26 EMLA.

The purpose of this trial was to determine if crop load and rootstock interacted to affect crop load. In 2006 and within the range of crop loads that were able to be imposed, there was no interaction (Figure 1). M.26 EMLA resulted in smaller fruit, but the relatively small crop load effect was consistent from rootstock to rootstock.

Table 9. Trunk cross-sectional area, root suckering, yield, yield efficiency, and fruit weight in 2006 of Gibson Golden Delicious trees on three rootstocks in the Massachusetts planting of the 2003 NC-140 Apple Rootstock Physiology Trial. All values are least-squares means, adjusted for missing subclasses.<sup>z</sup>

Rootstock	Trunk cross-sectional area (cm <sup>2</sup> )	Root suckers (no./tree)	Yield per tree (kg)	Yield efficiency (kg/cm <sup>2</sup> TCA)	Fruit weight (g)
G.16	12.4 a	0.0 a	5.7 a	0.46 ab	201 a
M.26 EMLA	14.7 a	0.0 a	4.1 a	0.26 b	168 b
M.9 NAKBT337	8.6 b	0.0 a	4.5 a	0.55 a	201 a

<sup>z</sup> Means were separated within columns by Tukey's HSD ( $P = 0.05$ ).





## USEFULNESS OF FINDINGS

We have further refined our understanding of the characteristics of several rootstocks grown under Massachusetts conditions with McIntosh, Gala, and Cameo as apple scion cultivars and Redhaven as a peach scion cultivar. Several rootstocks in the older plantings show great promise for potential commercial adoption.

In addition to the economic benefits associated with the

greater yield efficiency and fruit size of trees on some of these dwarfing rootstocks, significant benefits are realized by growers in Massachusetts selling fruit using pick-your-own techniques. These fully dwarf trees seem particularly suited to pick-your-own marketing, providing for significantly less loss due to fruit drop and poor quality. Further, significantly less pesticide is required to treat dwarf trees (low tree volume).

## WORK PLANNED FOR 2007

All existing plantings will be maintained in 2007. No new trials are planned. Final reports of the 1995 Massachusetts-

Maine-Nova Scotia Rootstock Trial and the 1996 McIntosh Rootstock Trial will be developed for publication.

## PUBLICATIONS

### Refereed Journal Articles

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### Non-refereed Journal Articles

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