



ANNUAL REPORT TO NC-140

Massachusetts Agricultural Experiment Station

November 2003 -- Kentville, Nova Scotia

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PROGRESS & PRINCIPAL ACCOMPLISHMENTS

1994 NC-140 Apple Rootstock Trial

Trunk cross-sectional area (TCA), root suckering, yield, yield efficiency, and fruit weight (Table 1) and tree height and canopy spread (Table 2) all were affected by rootstock in 2003 (tenth growing season). Largest trees were on V.1 and M.26 EMLA, and the smallest trees were on P.22, M.27 EMLA, B.491, and P.16. The greatest amount of cumulative (1994-2003) root

suckering resulted from trees on M.9 Pajam 2, M.9 Fleuren 56, P.16, and O.3, and the least resulted from trees on M.26 EMLA, P.2, and M.27 EMLA. V.1, M.26 EMLA, and M.9 Pajam 2 resulted in the greatest yields in 2003 and cumulatively (1996-2003), and P.22, M.27 EMLA, and B.491 resulted in the lowest. In 2003, M.9 NAKBT337 and M.9 Fleuren 56 produced in the most yield efficient trees, and P.22, and Mark produced in the least efficient. Cumulatively (1996-2003), the most efficient

Table 1. Trunk cross-sectional area, suckering, yield, yield efficiency, and fruit weight in 2003 of Gala trees on several rootstocks in the Massachusetts planting of the 1994 NC-140 Apple Rootstock Trial. All values are least-squares means, adjusted for missing subclasses and for crop load in the case of 2003 fruit weight.²

| Rootstock | Trunk cross-sectional area (cm ²) | Root suckers (no./tree, 1994-2003) | Yield per tree (kg) | | Yield efficiency (kg/cm ² TCA) | | Fruit weight (g) | |
|----------------|---|------------------------------------|---------------------|------------------------|---|------------------------|------------------|---------------------|
| | | | 2003 | Cumulative (1996-2003) | 2003 | Cumulative (1996-2003) | 2003 | Average (1996-2003) |
| B.9 | 41.6 fg | 15.3 bcd | 54 efg | 193 cdef | 1.29 abc | 4.67 a | 109 abc | 132 bcd |
| B.469 | 31.9 gh | 7.7 cd | 34 gh | 137 efg | 1.04 cd | 4.41 ab | 94 de | 124 d |
| B.491 | 20.8 hi | 10.5 bcd | 27 gh | 98 gh | 1.33 abc | 4.83 a | 107 abc | 126 cd |
| M.9 EMLA | 61.5 cdef | 13.7 bcd | 82 bcde | 264 bc | 1.36 abc | 4.35 ab | 113 abc | 140 abc |
| M.9 Fleuren 56 | 46.7 efg | 36.4 ab | 68 def | 223 cde | 1.43 ab | 4.82 a | 113 abc | 139 abc |
| M.9 Pajam 1 | 63.9 cde | 28.5 abc | 79 cde | 273 bc | 1.20 abc | 4.23 ab | 110 abc | 143 ab |
| M.9 Pajam 2 | 78.9 bc | 42.1 a | 103 abc | 346 ab | 1.33 abc | 4.43 ab | 109 abc | 140 abc |
| M.9 RN29 | 70.0 cd | 26.6 abcd | 96 abcd | 320 b | 1.38 ab | 4.56 ab | 111 abc | 142 ab |
| M.9 NAKBT337 | 56.9 def | 21.4 abcd | 83 abcde | 260 bcd | 1.46 a | 4.56 ab | 117 abc | 142 ab |
| M.26 EMLA | 94.8 ab | 2.4 d | 108 ab | 331 ab | 1.15 abcd | 3.57 b | 122 a | 149 a |
| M.27 EMLA | 14.0 hi | 8.0 cd | 18 h | 66 gh | 1.35 abc | 4.93 a | 117 ab | 130 bcd |
| Mark | 37.4 fgh | 22.6 abcd | 37 fgh | 157 defg | 0.99 cd | 4.16 ab | 96 cde | 132 bcd |
| O.3 | 57.7 def | 33.2 abc | 75 cde | 281 bc | 1.30 abc | 4.90 a | 102 abc | 128 bcd |
| P.2 | 57.8 def | 6.4 cd | 66 ef | 233 cd | 1.15 abcd | 4.04 ab | 109 abc | 140 abc |
| P.16 | 25.4 ghi | 36.9 ab | 34 gh | 119 fgh | 1.35 abc | 4.74 a | 114 abc | 136 abcd |
| P.22 | 8.5 i | 9.9 bcd | 7 h | 37 h | 0.83 d | 4.33 ab | 76 e | 107 e |
| V.1 | 104.4 a | 22.6 abcd | 115 a | 414 a | 1.09 bcd | 3.97 ab | 115 abc | 150 a |

² Means were separated within columns by Tukey's HSD ($P = 0.05$).

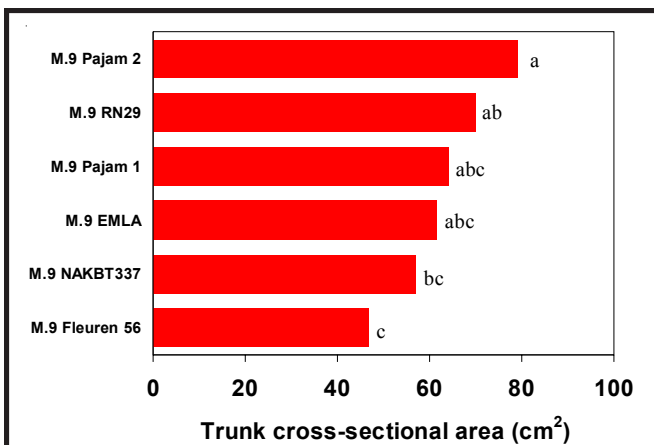


Figure 1. Trunk cross-sectional area of Gala trees on six M.9 strains in the 1994 NC-140 Apple Rootstock Trial in Massachusetts.

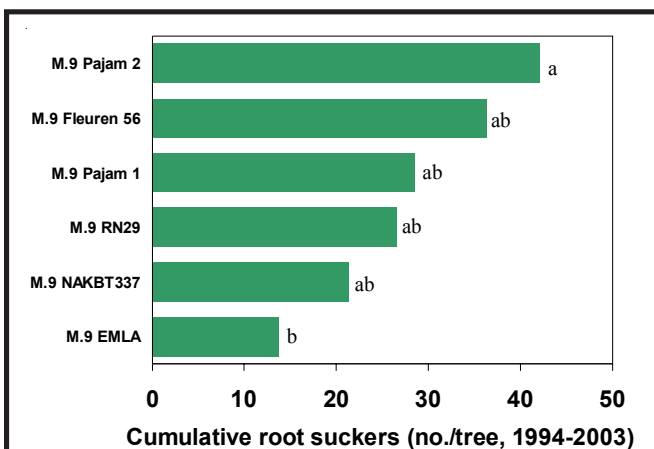


Figure 2. Root suckering of Gala trees on six M.9 strains in the 1994 NC-140 Apple Rootstock Trial in Massachusetts.

trees were on M.27 EMLA, O.3, B.491, M.9 Fleuren 56, P.16 and B.9, and the least efficient were on M.26 EMLA. In 2003, M.26 EMLA resulted in the largest fruit, and P.22, B.469, and Mark resulted in the smallest. Average fruit weight for the fruiting life of the planting (1996-2003) was greatest for trees on V.1 and

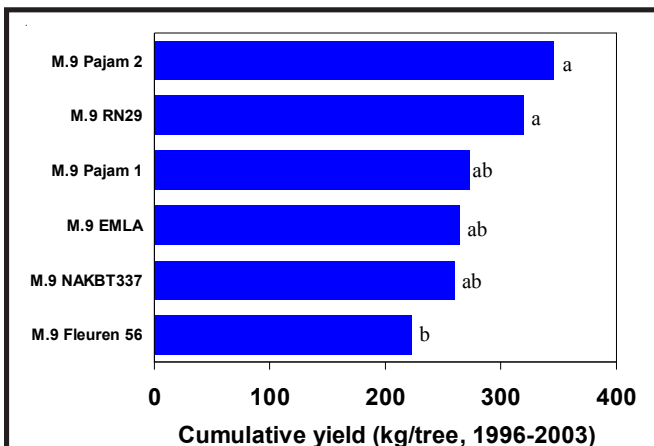


Figure 3. Cumulative yield of Gala trees on six M.9 strains in the 1994 NC-140 Apple Rootstock Trial in Massachusetts.

Table 2. Tree height and Canopy Spread in 2003 of Gala trees on several rootstocks in the Massachusetts planting of the 1994 NC-140 Apple Rootstock Trial. All values are least-squares means, adjusted for missing subclasses.^z

| Rootstock | Tree height (cm) | Canopy spread (cm) |
|----------------|------------------|--------------------|
| B.9 | 318 bcde | 260 cdef |
| B.469 | 244 ef | 234 def |
| B.491 | 208 f | 199 fg |
| M.9 EMLA | 345 ab | 308 bc |
| M.9 Fleuren 56 | 322 bcd | 285 cde |
| M.9 Pajam 1 | 354 ab | 315 bc |
| M.9 Pajam 2 | 360 ab | 347 ab |
| M.9 RN29 | 358 ab | 320 bc |
| M.9 NAKBT337 | 332 abc | 299 bed |
| M.26 EMLA | 400 a | 359 ab |
| M.27 EMLA | 188 f | 167 gh |
| Mark | 246 cdef | 247 cdef |
| O.3 | 364 ab | 296 bcd |
| P.2 | 354 ab | 295 cd |
| P.16 | 246 def | 217 efg |
| P.22 | 175 f | 119 h |
| V.1 | 401 a | 393 a |

^z Means were separated within columns by Tukey's HSD ($P = 0.05$).

M.26 EMLA and smallest for trees on P.22.

Since six strains of M.9 are included in this experiment, it is interesting to study variation among them. Trees on M.9 Pajam 2 were 69% larger than trees on M.9 Fleuren 56 (Figure 1). Trees on M.9 Pajam 2 produced 207% more root suckers than did trees on M.9 EMLA (Figure 2). Cumulative yield per tree (Figure 3) and canopy spread (Figure 4) followed a similar trend to TCA. Trees of the six strains had similar tree height, were similarly yield efficient, and resulted in similar fruit size.

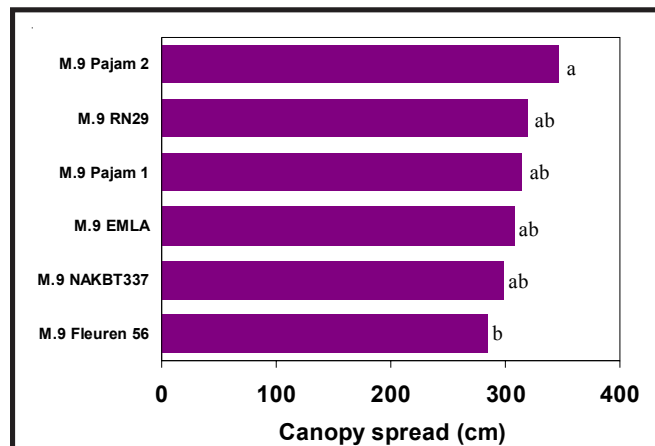


Figure 4. Canopy spread of Gala trees on six M.9 strains in the 1994 NC-140 Apple Rootstock Trial in Massachusetts.

Table 3. Trunk cross-sectional area, suckering, yield, yield efficiency, and fruit weight in 2003 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 and for crop load in the case of 2003 fruit weight.^z

| Rootstock | Trunk cross-sectional area (cm ²) | Root suckers (no./tree, 1998-2003) | Yield per tree (kg) | | Yield efficiency (kg/cm ² TCA) | | Fruit weight (g) | |
|-----------|---|------------------------------------|---------------------|------------------------|---|------------------------|------------------|---------------------|
| | | | 2003 | Cumulative (1999-2003) | 2003 | Cumulative (1999-2003) | 2003 | Average (1999-2003) |
| G.16 | 17.8 a | 0.4 a | 15.7 a | 40 a | 0.97 a | 2.26 a | 131 a | 104 b |
| M.9 | 11.7 b | 0.3 a | 6.5 a | 24 b | 0.56 a | 2.05 a | 162 a | 132 a |
| M.9 EMLA | 10.6 b | 0.3 a | 5.3 a | 20 b | 0.48 a | 1.89 a | 143 a | 125 a |

^z Means were separated within columns by Tukey's HSD ($P = 0.05$).

As a final evaluation of these results, all trees except those on M.26 EMLA were relatively yield efficient; however, fruit size was consistently in the highest category only for the M.9 strains, P.2, P.16, and V.1. Therefore, only P.16 among the ultra-dwarfs, P.2 and M.9 among the mid-dwarfs, and V.1 among the semi-dwarfs could be recommended from the Massachusetts planting of this trial.

1998 NC-140 Apple Rootstock Trial

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. The experiment was a randomized-complete-block design with ten replications. Means from the 2003 growing season are included in Table 3.

Rootstock significantly affected TCA after the sixth growing season (2003) (Table 3), with trees on G.16 significantly larger than those on M.9 or M.9 EMLA. Cumulative (1998-2003) root suckering was similar among the three rootstocks. Yield in 2003 was not different among trees on the three rootstocks, but cumulatively (2000-2003), trees on G.16 outyielded trees on M.9 or M.9 EMLA. In 2003 and cumulatively (2000-03), rootstocks resulted in similar yield

Table 4. Trunk cross-sectional area, suckering, yield, yield efficiency, and fruit weight in 2003 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 2003 fruit weight.^z

| Rootstock | Trunk cross-sectional area (cm ²) | Root suckers (no./tree, 1999-2003) | Yield per tree (kg) | | Yield efficiency (kg/cm ² TCA) | | Fruit weight (g) | |
|--------------|---|------------------------------------|---------------------|----------------------|---|----------------------|------------------|-------------------|
| | | | 2003 | Cumulative (2001-03) | 2003 | Cumulative (2001-03) | 2003 | Average (2001-03) |
| CG.3041 | 16.4 cd | 1.2 a | 23.4 bcd | 35 bcd | 1.42 ab | 2.14 ab | 162 a | 155 ab |
| CG.4013 | 29.9 a | 1.2 a | 42.0 a | 66 a | 1.41 ab | 2.19 a | 164 a | 160 ab |
| CG.5179 | 21.9 bc | 0.7 a | 30.5 ab | 49 ab | 1.40 ab | 2.25 a | 165 a | 158 ab |
| CG.5202 | 25.2 ab | 0.0 a | 31.3 ab | 49 ab | 1.29 ab | 2.01 ab | 161 a | 160 ab |
| G.16N | 13.3 d | 0.0 a | 16.0 bcd | 26 bcd | 1.12 ab | 1.82 ab | 154 a | 147 ab |
| G.16T | 14.6 cd | 0.2 a | 17.6 bcd | 28 bcd | 1.22 ab | 1.95 ab | 145 a | 144 ab |
| M.26 EMLA | 16.5 cd | 0.0 a | 15.0 cd | 20 cd | 0.88 b | 1.19 b | 162 a | 158 ab |
| M.9 NAKBT337 | 9.2 d | 0.0 a | 11.4 d | 17 d | 1.25 ab | 1.89 ab | 173 a | 169 a |
| Supporter 1 | 11.8 d | 0.0 a | 19.5 bcd | 30 bcd | 1.63 a | 2.42 a | 145 a | 139 ab |
| Supporter 2 | 15.3 cd | 0.6 a | 25.2 bcd | 37 bcd | 1.66 a | 2.50 a | 141 a | 134 b |
| Supporter 3 | 16.3 cd | 0.0 a | 25.3 bc | 41 bc | 1.56 a | 2.53 a | 145 a | 146 ab |

^z Means were separated within columns by Tukey's HSD ($P = 0.05$).

Table 5. Trunk cross-sectional area, suckering, yield, yield efficiency, and fruit weight in 2003 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 and crop load in the case of 2003 fruit weight.^z

| Rootstock | Trunk cross-sectional area (cm ²) | Root suckers (no./tree, 1999-2003) | Yield per tree (kg) | | Yield efficiency (kg/cm ² TCA) | | Fruit weight (g) | |
|-------------|---|------------------------------------|---------------------|----------------------|---|----------------------|------------------|-------------------|
| | | | 2003 | Cumulative (2001-03) | 2003 | Cumulative (2001-03) | 2003 | Average (2001-03) |
| CG.4814 | 13.1 c | 11.2 ab | 24.3 ab | 37 ab | 1.87 a | 2.82 a | 175 a | 154 a |
| CG.7707 | 16.8 c | 3.5 bc | 20.3 b | 29 bc | 1.20 ab | 1.73 b | 175 a | 168 a |
| G.30N | 31.5 a | 0.5 bc | 37.9 a | 53 a | 1.25 ab | 1.71 b | 175 a | 169 a |
| M.26 EMLA | 15.3 c | 0.0 c | 13.7 b | 19 c | 0.88 b | 1.23 b | 177 a | 168 a |
| M.7 EMLA | 30.6 ab | 15.2 a | 23.2 b | 30 bc | 0.75 b | 0.96 b | 153 a | 163 a |
| Supporter 4 | 29.7 b | 1.2 bc | 22.6 b | 32 bc | 0.79 b | 1.12 b | 164 a | 169 a |

^z Means were separated within columns by Tukey's HSD ($P = 0.05$).

efficiency. Also, they resulted in similar fruit size in 2003 and on average (2000-03).

1999 NC-140 Dwarf Apple Rootstock Trial

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. The planting included six replications in a randomized-complete-block design. Means from the 2003 growing season are included in Table 4.

After the fifth growing season (2003), largest trees were on CG.4013 and CG.5202, and the smallest were on M.9 NAKBT337 and G.16N. Cumulative suckering (1999-2003) was not affected by rootstock. CG.4013, CG.5202, and CG.5179 resulted in the most yield in 2003 and cumulatively (2001-03), and M.9 NAKBT337 and M.26 EMLA resulted in the least.

Table 6. Trunk cross-sectional area in October and cumulative suckering in 2003 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.^z

| Rootstock | Trunk cross-sectional area (cm ²) | Root suckers (no./tree, 2002-03) |
|-----------------|---|----------------------------------|
| B.9 (Europe) | 3.8 bc | 0.0 a |
| B.9 (Treco) | 4.0 bc | 0.0 a |
| M.26 EMLA | 5.4 abc | 0.0 a |
| M.26 NAKB | 6.5 a | 0.0 a |
| M.9 Bergmer 756 | 4.5 abc | 0.1 a |
| M.9 RN29 | 4.6 abc | 1.0 a |
| M.9 NAKBT337 | 3.5 c | 0.0 a |
| P.14 | 4.5 abc | 0.1 a |
| PiAu51-11 | 3.5 bc | 0.2 a |
| PiAu51-4 | 5.7 ab | 0.0 a |
| Supporter 4 | 3.8 bc | 0.0 a |

^z Means were separated within columns by Tukey's HSD ($P = 0.05$).

Table 7. Trunk cross-sectional area and cumulative suckering in 2003 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.^z

| Rootstock | Trunk cross-sectional area (cm ²) | Root suckers (no./tree, 2002-03) |
|------------|---|----------------------------------|
| Adesto 101 | 11.6 b | 0.0 a |
| Cadaman | 21.2 a | 0.0 a |
| Lovell | 19.7 a | 0.0 a |
| MRS | 13.2 b | 0.1 a |
| Penta | 9.1 b | 0.0 a |
| Pumiselect | 10.8 b | 0.0 a |
| VSV-1 | 8.5 b | 0.0 a |
| VVA-1 | 10.8 b | 0.3 a |

^z Means were separated within columns by Tukey's HSD ($P = 0.05$).

Table 8. Trunk cross-sectional area and root suckering in 2003 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.^z

| Rootstock | Trunk cross-sectional area (cm ²) | Root suckers (no./tree) |
|--------------|---|-------------------------|
| G.16 | 1.4 a | 0.0 a |
| M.26 EMLA | 1.3 a | 0.0 a |
| M.9 NAKBT337 | 1.3 a | 0.0 a |

^z Means were separated within columns by Tukey's HSD ($P = 0.05$).

Most efficient trees in 2003 were on Supporter 1, Supporter 2, and Supporter 3. The least efficient were on M.26 EMLA. Cumulatively (2001-03), the most efficient trees were on Supporter 1, Supporter 2, Supporter 3, CG.5179, and CG.4013, and the least efficient were on M.26 EMLA. Fruit size was not affected by rootstock in 2003, but on average (2001-03), M.9 NAKBT337 resulted in the largest fruit, and Supporter 2 resulted in the smallest.

1999 NC-140 Semidwarf Apple Rootstock Trial

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. The planting included six replications in a randomized-complete-block design. Means from the 2003 growing season are included in Table 5.

After the fifth growing season (2003), largest trees were on G.30N and M.7 EMLA, and the smallest were on M.26 EMLA, CG.4814, and CG.7707. Greatest cumulative (1999-

2003) root suckering was observed from trees on CG.4814 and M.7 EMLA, with the least from trees on M.26 EMLA, G.30N, and Supporter 4. G.30N and CG.4814 resulted in the most yield per tree in 2003 and cumulatively (2001-03), and M.26 EMLA, CG.7707, Supporter 4, and M.7 EMLA resulted in the least. Trees on CG.4814 were the most yield efficient in 2003, and trees on M.7 EMLA, Supporter 4, and M.26 EMLA were the least efficient. Cumulatively (2001-03), trees on CG.4814 were significantly more efficient than trees on the other rootstocks. Fruit weight was not affected in 2003 or on average (2001-03).

2002 NC-140 Apple Rootstock Trial

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 Research & Education Center in 2002. The planting included seven replications in a randomized-complete-block design. Means from the 2003 growing season included in Table 6. Rootstock affected TCA at the end of the second growing season (2003) but did not affect root suckering. The largest trees at planting were on M.26 NAKB and PiAu51-4, and the smallest were on B.9 (both strains), Supporter 4, PiAu 51-11, and M.9 NAKBT337.

2002 NC-140 Peach Rootstock Trial

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 planting included eight replications in a randomized-complete-block design. Means from the 2003 growing season included in Table 7. Largest trees at the end of

Table 9. Trunk cross-sectional area in 2003 of Cortland, Rogers Red McIntosh, Macoun, and Pioneer Mac trees on several rootstocks planted in 1995. All values are least-squares means adjusted for missing subclasses.^z

| Rootstock | Cortland | Macoun | McIntosh | Pioneer Mac | Average |
|--|----------|--------|----------|-------------|---------|
| <i>Trunk cross-sectional area (cm²)</i> | | | | | |
| B.146 | 8.8 | 12.3 | 3.4 | 13.0 | 9.3 fg |
| B.469 | 17.4 | 15.3 | 18.3 | 18.1 | 17.3 ef |
| B.491 | 10.6 | 14.4 | 12.7 | 11.7 | 12.4 fg |
| M.9 | 28.3 | 24.9 | 29.2 | 22.5 | 26.2 cd |
| M.9 NAKBT337 | 24.3 | 25.3 | 30.7 | 31.7 | 28.0 c |
| Mark | 43.9 | 41.8 | 38.4 | 47.0 | 42.8 b |
| P.2 | 27.5 | 26.6 | 22.5 | 31.7 | 27.1 cd |
| P.16 | 4.8 | 5.5 | 4.7 | 8.0 | 5.6 g |
| P.22 | 7.0 | 7.7 | 7.1 | 6.9 | 7.2 g |
| V.1 | 47.0 | 55.5 | 55.2 | 54.7 | 52.1 a |
| V.3 | 20.0 | 20.1 | 19.9 | 23.5 | 20.9 de |
| Average | 22.7 a | 22.7 a | 22.0 a | 24.4 a | |

^z Rootstock means and cultivar means were separated by Tukey's HSD ($P = 0.05$). Rootstock means were not separated within cultivar, since cultivar and rootstock did not interact significantly.

Table 10. Yield in 2003 and cumulative yield of Cortland, Rogers Red McIntosh, Macoun, and Pioneer Mac trees on several rootstocks planted in 1995. All values are least-squares means adjusted for missing subclasses.^z

| Rootstock | Cortland | Macoun | McIntosh | Pioneer Mac | Average |
|--|----------|--------|----------|-------------|---------|
| <i>Yield per tree (2003, kg)</i> | | | | | |
| B.146 | 3.6 f | 9.6 b | 3.3 d | 6.8 cd | 5.8 d |
| B.469 | 15.3 def | 17.7 b | 17.8 cd | 21.7 abc | 18.1 c |
| B.491 | 9.5 ef | 23.4 b | 16.8 cd | 13.4 bcd | 15.8 c |
| M.9 | 20.1 cd | 25.5 b | 30.8 abc | 24.7 ab | 25.3 b |
| M.9 NAKBT337 | 19.3 cd | 19.2 b | 28.4 abc | 30.8 a | 24.4 b |
| Mark | 40.3 a | 42.9 a | 35.6 a | 34.8 a | 38.4 a |
| P.2 | 22.9 bc | 23.2 b | 18.2 cd | 23.5 abc | 21.9 bc |
| P.16 | 5.5 f | 11.0 b | 6.4 d | 10.2 cd | 8.3 d |
| P.22 | 5.4 f | 5.3 b | 7.2 d | 6.7 d | 6.1 d |
| V.1 | 31.4 ab | 46.2 a | 33.6 ab | 34.0 a | 36.3 a |
| V.3 | 15.9 cde | 27.0 b | 21.5 bc | 22.4 abc | 21.7 bc |
| Average | 17.2 b | 22.8 a | 20.0 ab | 20.8 ab | |
| <i>Cumulative yield per tree (1997-2003, kg)</i> | | | | | |
| B.146 | 17 e | 26 d | 9 e | 23 e | 18 d |
| B.469 | 48 de | 45 cd | 48 cd | 50 cde | 48 c |
| B.491 | 33 e | 63 cd | 40 cde | 35 de | 43 cd |
| M.9 | 71 bcd | 82 bc | 83 ab | 66 abc | 75 b |
| M.9 NAKBT337 | 67 bcd | 60 cd | 73 abc | 76 abc | 69 b |
| Mark | 127 a | 116 ab | 100 a | 90 ab | 108 a |
| P.2 | 76 bc | 80 bc | 61 bc | 71 abc | 72 b |
| P.16 | 23 e | 28 d | 24 de | 35 de | 28 d |
| P.22 | 26 e | 16 d | 25 de | 24 e | 24 d |
| V.1 | 93 b | 131 a | 84 ab | 91 a | 100 a |
| V.3 | 60 cd | 77 c | 73 abc | 62 bcd | 68 b |
| Average | 58 a | 66 a | 56 a | 57 a | |

^z Rootstock and cultivar means were separated by Tukey's HSD ($P = 0.05$).

the second growing season (2003) were on Cadaman and Lovell, significantly larger than trees on the other rootstocks. Rootstock did not affect root suckering.

2003 NC-140 Apple Rootstock Physiology Trial

As part of the 2003 NC-140 Apple Rootstock Trial, a planting of Gibson Golden Delicious on 3 rootstocks was established at the University of Massachusetts Cold Spring Orchard Research & Education Center in 2003. The planting included ten trees of each rootstock in a completely random design. Means from the 2003 growing season included in Table 8. After the first growing season, rootstock did not affect trunk cross-sectional area or root suckering.

1995 MA-ME-NS Scion/Rootstock Trial

In 1995, a trial was established at three locations

(Belchertown, MA, Monmouth, ME, and Kentville, NS) including Rogers Red McIntosh, Cortland, Macoun, and Pioneer Mac on 11 different rootstocks. The experiment was a randomized-complete-block/split-plot design at each site, with cultivar as the whole plot and rootstock as the split plot. Each site included seven replications. Only Massachusetts data are presented in this report.

At the end of the ninth growing season (2003), trunk cross-sectional area was not affected by cultivar or the interaction of cultivar and rootstock; however, rootstock affected TCA significantly (Table 9). Specifically, across all cultivars, the largest trees were on V.1, and the smallest were on P.16 and P.22.

Yield in 2003 was affected by cultivar, rootstock, and the interaction of cultivar and rootstock (Table 10). Over all rootstocks, Macoun trees yielded more than Cortland trees. McIntosh and Pioneer Mac yielded intermediately. Over all cultivars, trees on V.1 and Mark yielded the most, and those on

Table 11. Yield efficiency in 2003 and cumulative yield efficiency of Cortland, Rogers Red McIntosh, Macoun, and Pioneer Mac trees on several rootstocks planted in 1995. All values are least-squares means adjusted for missing subclasses.^z

| Rootstock | Cortland | Macoun | McIntosh | Pioneer Mac | Average |
|---|----------|---------|----------|-------------|-----------|
| <i>Yield efficiency (2003, kg/cm² TCA)</i> | | | | | |
| B.146 | 0.41 c | 0.69 b | 0.79 ab | 0.56 c | 0.59 d |
| B.469 | 0.90 abc | 1.12 b | 1.01 ab | 1.21 ab | 1.06 bc |
| B.491 | 0.99 ab | 1.59 ab | 1.31 a | 1.15 ab | 1.26 ab |
| M.9 | 0.70 bc | 1.04 b | 1.06 ab | 1.13 ab | 0.98 c |
| M.9 NAKBT337 | 0.79 abc | 0.98 b | 0.97 ab | 1.07 abc | 0.95 cd |
| Mark | 0.94 abc | 1.07 b | 0.92 ab | 0.75 bc | 0.92 cd |
| P.2 | 0.84 abc | 0.98 b | 0.92 ab | 0.77 bc | 0.88 cd |
| P.16 | 1.16 a | 2.03 a | 1.35 a | 1.35 a | 1.47 a |
| P.22 | 0.79 abc | 0.79 b | 0.94 ab | 1.01 abc | 0.88 cd |
| V.1 | 0.69 bc | 0.89 b | 0.61 b | 0.63 c | 0.70 d |
| V.3 | 0.80 abc | 1.35 ab | 1.09 ab | 0.99 abc | 1.06 bc |
| Average | 0.82 c | 1.14 a | 1.00 ab | 0.96 b | |
| <i>Cumulative yield efficiency (1997-2003, kg/cm² TCA)</i> | | | | | |
| B.146 | 2.02 | 2.15 | 2.32 | 1.78 | 2.07 de |
| B.469 | 2.99 | 2.96 | 2.77 | 2.84 | 2.89 bcd |
| B.491 | 3.60 | 4.29 | 3.18 | 3.03 | 3.52 b |
| M.9 | 2.65 | 3.33 | 2.81 | 2.98 | 2.94 bcd |
| M.9 NAKBT337 | 2.65 | 3.00 | 2.54 | 2.65 | 2.71 bcde |
| Mark | 3.00 | 2.94 | 2.59 | 1.95 | 2.62 cde |
| P.2 | 2.87 | 3.16 | 3.72 | 2.41 | 3.04 bcd |
| P.16 | 4.67 | 5.39 | 5.23 | 4.56 | 4.96 a |
| P.22 | 3.84 | 2.98 | 3.69 | 3.45 | 3.49 bc |
| V.1 | 2.05 | 2.51 | 1.53 | 1.68 | 1.94 e |
| V.3 | 3.08 | 3.82 | 3.69 | 2.74 | 3.33 bc |
| Average | 3.04 a | 3.32 a | 3.10 a | 2.73 a | |

^zRootstock and cultivar means were separated by Tukey's HSD ($P = 0.05$). For cumulative yield efficiency, rootstock means were not separated within cultivar, since cultivar and rootstock did not interact significantly.

B.146, P.16, and P.22 yielded the least. Although significant, the interaction of rootstock and cultivar did not result in dramatic variation in the relative affects of rootstock from cultivar to cultivar. Cumulative yields (1997-2003) were affected by rootstock and the interaction of cultivar and rootstock, but not by cultivar (Table 10). Over all cultivars, Mark and V.1 resulted in the greatest cumulative yields per tree, and B.146, P.22, and P.16 resulted in the least. Although the interaction of cultivar and rootstock was statistically significant, as with yield per tree in 2003, little variation in rootstock response existed among cultivars.

Yield efficiency in 2003 was affected by cultivar, rootstock, and the interaction of cultivar and rootstock (Table 11). Over all rootstocks, Macoun trees were more efficient than Pioneer Mac, with McIntosh intermediate, and all three were more efficient than Cortland trees. Overall cultivars, Trees on P.16 and B.491 were the most efficient, and those on V.1 and B.146

were the least efficient. As with yield, the significant interaction of cultivar and rootstock was not the result of dramatic differences in the relative effects of rootstock on yield efficiency among cultivars. Cumulative yield efficiency (1997-2003) was affected only by rootstock (Table 11). Specifically, trees on P.16 were most efficient, and those on V.1 and B.146 were the least efficient.

In 2003, fruit weight was affected by cultivar, rootstock, and the interaction of cultivar and rootstock (Table 12). Across all rootstocks, Cortland produced the largest fruit, and Macoun produced the smallest. McIntosh and Pioneer Mac fruit were of similar weight, intermediate to and significantly different from the other two. Across all cultivars, M.9, M.9 NAKBT337, V.1, and V.3 resulted in the largest fruit, and B.146 and P.22 resulted in the smallest. Little substantial variation in these relative differences existed among cultivars. Averaged across the fruiting life (1997-2003) of the trees, fruit weight was

Table 12. Fruit weight in 2003 and average fruit weight of Cortland, Rogers Red McIntosh, Macoun, and Pioneer Mac trees on several rootstocks planted in 1995. All values are least-squares means adjusted for missing subclasses and for crop load in the case of fruit weight in 2003.^z

| Rootstock | Cortland | Macoun | McIntosh | Pioneer Mac | Average |
|--|----------|--------|----------|-------------|---------|
| <i>Fruit weight (2003, g)</i> | | | | | |
| B.146 | 137 b | 109 b | 120 c | 113 d | 120 e |
| B.469 | 198 ab | 118 b | 155 ab | 143 abcd | 153 cd |
| B.491 | 218 a | 126 ab | 168 ab | 144 abcd | 165 bc |
| M.9 | 240 a | 156 a | 174 a | 158 ab | 183 a |
| M.9 NAKBT337 | 236 a | 137 ab | 164 ab | 168 a | 177 ab |
| Mark | 226 a | 143 ab | 157 ab | 140 abcd | 166 bc |
| P.2 | 235 a | 128 ab | 157 ab | 139 abcd | 165 bc |
| P.16 | 197 ab | 116 b | 147 abc | 138 bcd | 151 cd |
| P.22 | 162 b | 121 ab | 140 bc | 125 cd | 134 de |
| V.1 | 222 a | 155 ab | 154 ab | 149 abc | 171 ab |
| V.3 | 237 a | 142 ab | 160 ab | 151 ab | 175 ab |
| Average | 203 a | 139 c | 154 b | 144 bc | |
| <i>Average fruit weight (1997-2003, g)</i> | | | | | |
| B.146 | 162 d | 122 b | 121 d | 141 cd | 136 f |
| B.469 | 193 c | 139 ab | 155 bc | 146 cd | 158 de |
| B.491 | 206 bc | 139 ab | 160 abc | 150 bcd | 163 cd |
| M.9 | 229 a | 150 a | 175 a | 162 abc | 179 a |
| M.9 NAKBT337 | 224 ab | 151 a | 166 ab | 171 a | 178 ab |
| Mark | 220 ab | 150 a | 163 ab | 155 abcd | 172 abc |
| P.2 | 221 ab | 140 ab | 157 abc | 152 abcd | 168 bcd |
| P.16 | 189 cd | 131 b | 135 cd | 136 d | 148 ef |
| P.22 | 169 d | 139 ab | 144 cd | 138 d | 148 ef |
| V.1 | 228 ab | 157 a | 170 ab | 167 ab | 180 a |
| V.3 | 226 ab | 148 ab | 162 ab | 159 abc | 174 abc |
| Average | 206 a | 143 c | 155 b | 152 b | |

^z Rootstock and cultivar means were separated by Tukey's HSD ($P = 0.05$).

affected by cultivar, rootstock, and the interaction of cultivar and rootstock (Table 12). Over all rootstocks, the cultivar differences were similar to 2003. Over all cultivars, V.1, M.9 NAKBT337, M.9, V.3, and Mark resulted in the largest fruit, and B.146, P.16, and P.22 resulted in the smallest. As in 2003, the relative rootstock effects were roughly similar for the four cultivars.

1996 McIntosh Rootstock Trial

In 1996, a trial was established at the University of Massachusetts Cold Spring Orchard Research & Education Center including Rogers Red McIntosh on V.1, V.2, V.3, V.4, V.7, and M.26 EMLA. The experiment was a randomized-complete-block design with seven replications. Means from the 2003 growing season are included in Table 13.

After the eighth growing season (2003), trees on V.4 had the largest trunk cross-sectional area, the greatest yield in 2003 and cumulatively (1998-2003), the lowest yield efficiency in

2003 and cumulatively. The most yield efficient trees in 2003 and cumulatively were on V.3. Rootstock did not affect fruit weight in 2003 or on average (1998-2003).

2002 MA-NJ Cameo Rootstock Trial

In 2002, a trial was established in Belchertown, MA and Pittstown, NJ including Cameo on B.9, G.16, and M.9 NAKBT337. The experiment was a randomized-complete-block design with ten replications at each site. Only Massachusetts data are presented here. Means from the 2003 growing season are included in Table 14.

Rootstock affected trunk circumference at the end of the 2003 growing season. Specifically, trees on G.16 were significantly larger than those on B.9 or M.9 NAKBT337. In 2003, differences in root suckering, bloom density, yield, and yield efficiency were nonsignificant. Fruit weight from trees on B.9 was significantly larger than for fruit from trees on M.9 NAKBT337 in 2003.

Table 13. Trunk cross-sectional area, yield, yield efficiency, and fruit weight in 2003 of Rogers Red McIntosh trees on several rootstocks planted in 1996. All values are least-squares means, adjusted for missing subclasses.^z

| Rootstock | Trunk cross-sectional area (cm ²) | Yield per tree (kg) | | Yield efficiency (kg/cm ² TCA) | | Fruit weight (g) | |
|-----------|---|---------------------|------------------------|---|------------------------|------------------|---------------------|
| | | 2003 | Cumulative (1998-2003) | 2003 | Cumulative (1998-2003) | 2003 | Average (1998-2003) |
| V.1 | 20.4 b | 14.1 ab | 63 b | 0.66 ab | 3.06 b | 121 a | 125 a |
| V.2 | 28.9 b | 24.6 ab | 78 b | 0.80 ab | 2.55 b | 143 a | 137 a |
| V.3 | 14.9 b | 12.6 b | 56 b | 0.84 a | 3.80 a | 134 a | 125 a |
| V.4 | 80.1 a | 39.1 a | 129 a | 0.48 b | 1.66 c | 128 a | 137 a |
| V.7 | 29.2 b | 17.4 ab | 77 b | 0.65 ab | 2.66 b | 132 a | 134 a |
| M.26 EMLA | 27.5 b | 22.2 ab | 79 b | 0.81 ab | 2.95 b | 138 a | 135 a |

^z Means were separated within columns by Tukey's HSD ($P = 0.05$).

Table 14. Trunk cross-sectional area, root suckering, bloom density, yield, yield efficiency, and fruit weight in 2003 of Cameo trees on three rootstocks planted in 2002.^z

| Rootstock | Trunk cross-sectional area (cm ²) | Root suckers (no./tree, 2002-03) | Bloom density (clusters/cm ² TCA) | Yield per tree (kg, 2003) | Yield efficiency (kg/cm ² TCA, 2003) | Fruit weight (g, 2003) |
|--------------|---|----------------------------------|--|---------------------------|---|------------------------|
| B.9 | 4.0 b | 0.0 a | 2.0 a | 1.6 a | 0.4 a | 208 a |
| G.16 | 6.4 a | 0.0 a | 1.3 a | 1.3 a | 0.2 b | 198 ab |
| M.9 NAKBT337 | 4.7 b | 0.4 a | 1.4 a | 0.9 a | 0.2 b | 172 b |

^z Means were separated within columns by Tukey's HSD ($P = 0.05$).

USEFULNESS OF FINDINGS

We have defined further the characteristics of several rootstocks grown under Massachusetts conditions with McIntosh, Pioneer Mac, Gala, Ginger Gold, Cortland, Macoun, 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. Strains of M.9 continued to perform well.

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.

WORK PLANNED FOR 2003

All existing plantings will be maintained in 2004. No new trials are planned. A final report of the Massachusetts-

Pennsylvania-New Brunswick Ginger Gold/Rootstock Trial will be developed for publication.

PUBLICATIONS

Autio, W.R., J.R. Schupp, C.G. Embree, and R.E. Moran. 2003. Early performance of 'Cortland,' 'Macoun,' 'McIntosh,' and 'Pioneer Mac' apple trees on various rootstocks in Maine, Massachusetts, and Nova Scotia. *J. Amer. Pomological Soc.* 57:7-14.

ABSTRACTS

Autio, W.R., J. Krupa, and J. Clements. 2003. Does rootstock differentially affect performance of 'Cortland,' 'Macoun,' 'McIntosh,' and 'Pioneer Mac' apple trees?" *HortScience* 38:665.

Autio, W.R., R. Crassweller, and J.P. Privé. 2003. Rootstock affects performance of 'Ginger Gold' apple trees. *HortScience* 38:667.

EXTENSION PRESENTATIONS

Autio, W.R. "Current rootstock recommendations from research in Massachusetts and elsewhere." June 10, 2003, Richmond, MA. 25 in attendance.

Autio, W.R. "Current rootstock recommendations from research in Massachusetts and elsewhere." June 12, 2003, Westport, MA. 33 in attendance.

Autio, W.R. "Current rootstock recommendations from research in Massachusetts and elsewhere." June 11, 2003, Stow, MA. 46 in attendance.