ANNUAL REPORT TO NC-140

Massachusetts Agricultural Experiment Station

November, 2017 -- Wenatchee, WA

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2009 NC-140 Peach

As part of the 2009 NC-140 Peach Rootstock Trial, a planting of Redhaven on 15 rootstocks was established at the University of Massachusetts Cold Spring Orchard Research & Education Center. Trees have grown well during their nine seasons. It is important to note that these trees experienced a heavy snowstorm at the end of October 2011. Leaves were still present, and some scaffold breakage occurred. Where possible, scaffolds were pulled back and bolted into place. Other than the bolts in trees, very little evidence of this damage persists, even after six years. The planting includes eight replications in a randomized-complete-block design.

Means from 2017 (9th growing season) are presented on Figure 1 and Table 1.

At the end of the 2017 season, largest trees were on Guardian, Lovell, and Krymsk 86, and smallest trees were on Controller 5, Krymsk 1, and *Prunus americana* (Table 1, Figure 1). Tallest trees were on Atlas, Guardian, HBOK 32, KV010-127, and Viking, and the shortest trees were on Krymsk 1 and Controller 5 (Table 1). Widest canopies were measured for trees on Guardian, Atlas, Krymsk 86, Lovel, Viking, and Mirobac, and the narrowest were for trees on Krymsk 1 and Controller 5 (Table 1). Significantly more suckering occurred from trees on *P. americana* than from any other rootstock (Table 1).

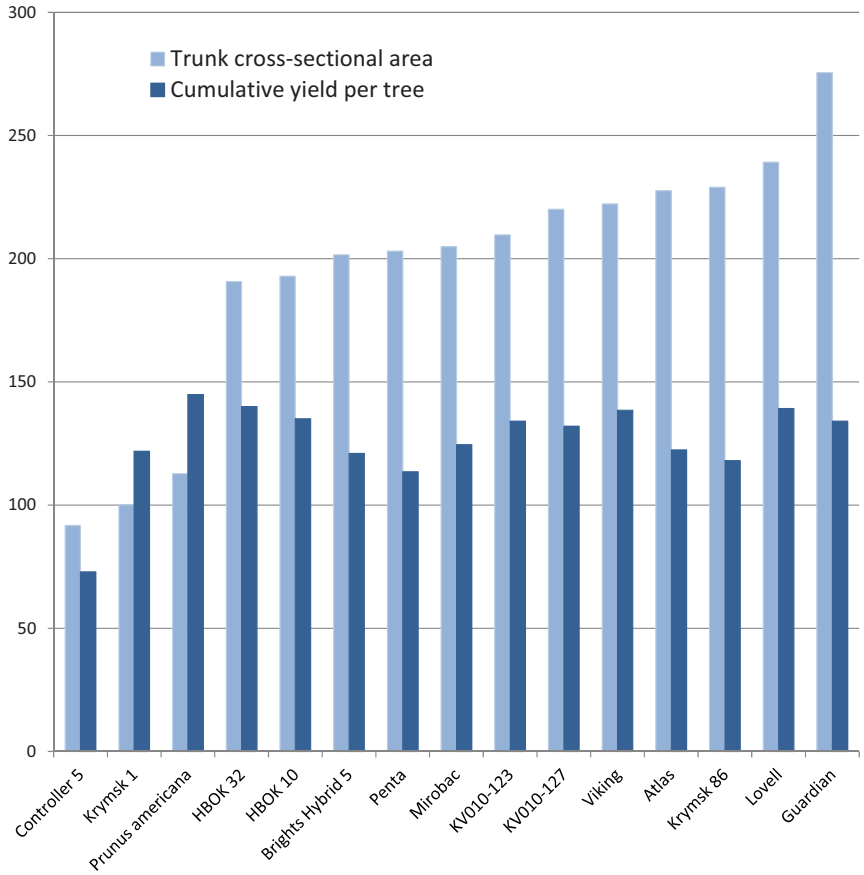

Figure 1. Trunk cross-sectional area (cm^2) and cumulative yield per tree (2011-17, kg) in 2017 of Redhaven peach trees in the 2009 NC-140 Peach Rootstock Trial.

The highest yielding trees in 2017 were on HBOK 32, and the lowest yielding were on KV010-127, Guardian, and Atlas (Table 1). On a cumulative basis (2011-17), yield was similar among most trees, except that yield from trees on Controller 5 was significantly lower than all others (Table 1, Figure 1).

The Most yield efficienct trees in 2017 were on *P. americana*, Controller 5, and Krymsk 1 (Table 1). Cumulatively (2011-17), yield efficiency was greatest for trees

Table 1. Tree and yield characteristics in 2017 of Redhaven peach trees in the 2009 NC-140 Peach Rootstock Trial at the UMass Cold Spring Orchard Research & Education Center, Belchertown, MA.

Rootstock	Trunk cross-sectional area (cm^2)	Tree height (m)	Canopy spread (m)	Cumulative root suckers (2009-17, no.)	Yield per tree (kg)	Cumulative yield per tree (2011-17, kg)	Yield efficiency (kg/cm^2)	Cumulative yield efficiency (2011-17, kg/cm^2)	Fruit weight (g)	Average fruit weight (2011-17, g)
Atlas	228 bc	2.9 a	4.6 abc	0.1 b	13.3 b	122 a	0.06 d	0.55 c	216 a	191 a
Brights Hybrid 5	202 bc	2.7 abc	4.4 abcd	0.0 b	15.7 ab	121 a	0.08 cd	0.60 bc	218 a	183 a
Controller 5	92 d	2.4 bc	3.7 ef	0.0 b	15.7 ab	73 b	0.18 ab	0.83 b	206 a	179 a
Guardian	275 a	2.9 a	4.9 a	1.1 b	13.4 b	134 a	0.05 d	0.50 c	190 a	189 a
HBOK 10	193 bc	2.6 abc	4.2 bcd	0.5 b	22.4 ab	135 a	0.12 bcd	0.74 bc	250 a	190 a
HBOK 32	191 c	2.9 a	4.3 bcd	0.9 b	24.0 a	140 a	0.13 abc	0.74 bc	209 a	183 a
KV010-123	210 bc	2.7 ab	4.6 abc	0.7 b	14.8 ab	134 a	0.07 cd	0.65 bc	211 a	185 a
KV010-127	220 bc	2.8 a	4.7 ab	2.1 b	12.8 b	132 a	0.06 d	0.61 bc	213 a	186 a
Krymsk 1	100 d	2.3 c	3.5 f	9.1 b	16.3 ab	122 a	0.17 ab	1.26 a	196 a	188 a
Krymsk 86	229 abc	2.7 abc	4.6 abcd	0.0 b	18.4 ab	118 a	0.08 cd	0.53 c	206 a	184 a
Lovell	239 ab	2.7 ab	4.5 abcd	0.0 b	15.8 ab	139 a	0.07 cd	0.58 bc	182 a	185 a
Mirobac	205 bc	2.8 ab	4.4 abcd	7.3 b	16.4 ab	125 a	0.08 cd	0.62 bc	200 a	178 a
Prunus americana	113 d	2.5 abc	4.1 cde	230.4 a	20.4 ab	145 a	0.19 a	1.33 a	248 a	193 a
Penta	203 bc	2.6 abc	4.1 de	19.9 b	19.3 ab	114 a	0.10 cd	0.56 c	207 a	189 a
Viking	222 bc	2.8 a	4.5 abcd	0.6 b	19.0 ab	139 a	0.09 cd	0.64 bc	198 a	184 a

Means separation within columns by Tukey's HSD (P = 0.05).

on *P. americana* and Krymsk 1, and lowest for trees on Guardian, Krymsk 86, Atlas, and Penta (Table 1). Neither fruit size in 2017 nor on average (2011-17) was different among rootstocks (Table 1).

At the end of this trial, it is interesting to note that the yield per tree of the significantly smaller than average Krymsk 1 and *P. americana* was comparable to much larger trees. In fact, *P. americana* resulted in the greatest cumualtive yield. *P. americana* would seem to be an excellent candidate for a dwarfing peach rootstock; however, its ability to produce large numbers of root suckers precludes its usefulness. Krymsk 1, did not result in as great a yield, but yield per tree was statistically similar to *P. americana*, trees were slightly but not statistically smaller, and it produced relativley few root suckers. Krymsk 1 should be considered for more significant trial as a potentially valuable dwarf (~50%) peach rootstock.

2010 NC-140 Apple

As part of the 2010 NC-140 Apple Rootstock Trial, a planting of Honeycrisp on 31 rootstocks was established at the University of Massachusetts Cold Spring Orchard Research & Education Center. Please note that one rootstock (B.70-20-20) was removed from the trial after five growing seasons. In 2010, trees in this planting grew relatively little, but growth has been good in the last 7 seasons. The planting includes four replications in a randomized-complete-block design, with up to three trees of a single rootstock per replication. Trees have been trained as Tall Spindles.

Means from 2017 (8th growing season) are included in Table 2 and Figure 2.

At the end of the 2017 growing season, trees with the greatest trunk

cross-sectional area were on B.64-194, B.70-6-8, B.7-3-150, and B.67-5-32, and those with the smallest were on B.71-7-22 (Table 2, Figure 2). Tallest trees were on B.70-6-8, B.67-5-32, and B-64-194, and shortest trees were on CG.2034, G.935TC, B.9, and M.9 Pajam 2 (Table 2). Trees with the widest canopies were on B.7-3-150 and CG.4004, and those with the narrowest canopies were on B.71-7-22, B.9, and CG.2034 (Table 2)

The greatest number of root suckers were produced (cumulatively, 2010-17) by CG.4214, G.202N, and M.9 Pajam 2, and the fewest were produced by trees on CG.2034, B.64-194, B.10, and B.70-6-8 (Table 2).

In 2017, yield was greatest from trees on B.7-3-150 and CG.4004 and least from trees on B.71-7-22 (Table 2). Cumulatively (2013-17), greatest yields were harvested from trees on CG.3001, G.202N, CG.4004, and G.935N, and lowest yields were harvested from trees on B.71-7-22 (Table 2).

The most yield efficient trees in 2017 were on G.11, G.41N, B.9, and M.9 NAKBT337, and the least yield efficient trees were on PiAu 9-90, B.64-194, and B.67-5-32 (Table 2). Cumulatively (2013-17), the most yield efficient trees were on G.11, G.935N, and CG.4003, and the least were on PiAu 9-90, B.64-194, and B.67-5-32 (Table 2).

Figure 2 presents the trees from those with the largest trunk-cross-sectional area at the top to those with the

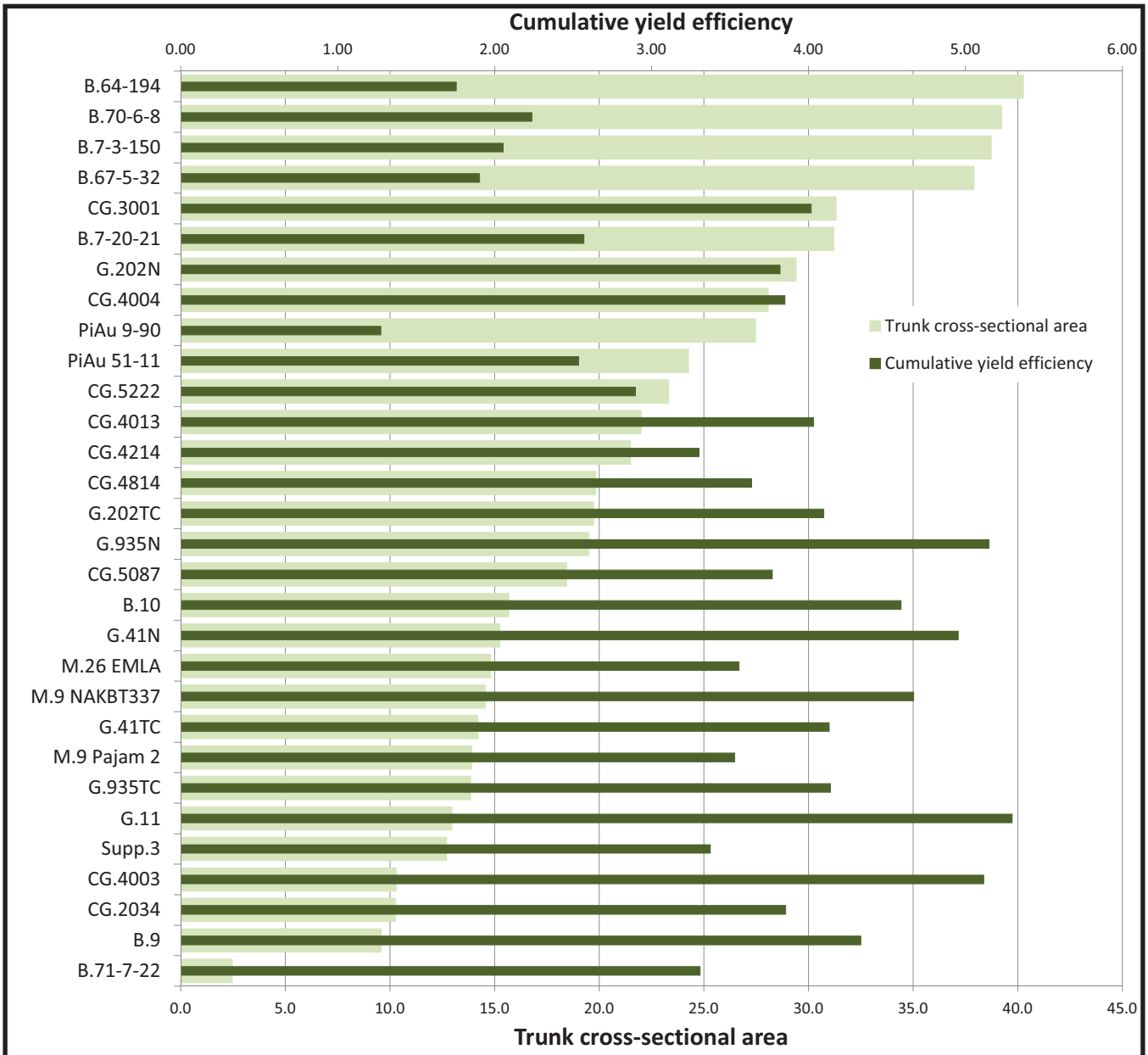

Figure 2. Trunk cross-sectional area (cm^2) and cumulative yield efficiency (kg/cm^2 TCA, 2013-17) in 2017 of Honeycrisp apple trees on various rootstocks in the 2010 NC-140 Honeycrisp Apple Rootstock Trial.

Table 2. Tree and yield characteristics in 2017 of Honeycrisp apple trees on various rootstocks in the 2010 NC-140 Honeycrisp Apple Rootstock Trial at the UMass Cold Spring Orchard Research & Education Center, Belchertown, MA.

Rootstock	Survival (%)	Trunk cross-sectional area (cm^2)	Tree height (m)	Canopy spread (m)	Cumulative root suckers (2010-17, no.)	Zonal chlorosis (%)	Yield per tree (kg)	Cumulative yield per tree (2013-17, kg)	Yield efficiency (kg/cm^2 TCA)	Cumulative yield efficiency (2013-17, kg/cm^2 TCA)	Fruit weight (g)	Average fruit weight (2013-17, g)
B.9	100	9.6	2.5	1.3	22.0	55.4	10.9	41.3	1.13	4.33	230	227
B.10	100	15.7	2.9	1.8	1.5	25.6	18.5	70.6	1.20	4.59	241	240
B.7-3-150	100	38.7	4.0	2.2	5.2	15.3	27.6	78.3	0.74	2.06	259	262
B.7-20-21	100	31.2	3.5	2.0	9.9	31.3	21.9	76.9	0.72	2.57	238	237
B.64-194	100	40.3	4.0	2.1	1.4	28.7	20.9	71.3	0.52	1.76	251	249
B.67-5-32	100	37.9	4.1	1.9	4.1	19.2	20.1	66.8	0.59	1.90	243	252
B.70-6-8	100	39.2	4.1	2.0	1.9	12.1	24.1	85.7	0.63	2.24	241	248
B.71-7-22	100	2.5	1.3	0.8	9.7	94.6	2.0	8.4	0.75	3.31	146	158
G.11	100	13.0	3.1	1.7	19.9	23.7	16.2	69.9	1.22	5.30	247	240
G.41N	100	15.2	3.0	1.6	2.3	44.7	17.1	77.1	1.13	4.95	235	244
G.41TC	100	14.2	2.7	1.5	20.0	62.5	13.4	58.6	0.99	4.13	250	245
G.202N	100	29.4	3.2	2.0	51.7	27.1	22.4	110.8	0.78	3.82	226	244
G.202TC	100	19.7	3.4	1.8	43.5	21.2	17.8	82.4	0.90	4.10	252	225
G.935N	100	19.5	3.2	1.7	32.6	46.9	20.7	101.1	1.05	5.15	223	228
G.935TC	100	13.9	2.4	1.8	40.6	56.2	14.6	60.3	1.00	4.14	210	220
CG.2034	100	10.3	2.4	1.4	0.6	36.7	10.1	41.6	0.97	3.85	188	204
CG.3001	50	31.3	3.4	2.0	5.3	30.0	19.7	126.2	0.63	4.02	244	246
CG.4003	100	10.3	2.8	1.5	4.6	26.5	11.3	54.1	1.06	5.12	195	195
CG.4004	100	28.1	3.6	2.1	23.8	18.8	27.4	108.0	0.98	3.85	241	248
CG.4013	100	22.0	3.8	1.9	40.0	37.4	22.3	93.1	1.00	4.03	221	220
CG.4214	100	21.5	3.5	2.1	77.9	80.6	19.3	70.8	0.91	3.30	225	235
CG.4814	100	19.8	3.1	1.6	40.9	56.3	16.6	70.9	0.84	3.64	223	220
CG.5087	100	18.4	3.3	1.7	13.4	93.1	10.6	69.9	0.66	3.77	192	210
CG.5222	100	23.3	3.3	1.9	39.7	57.7	17.8	65.8	0.83	2.90	221	221
Supp.3	100	12.7	3.0	1.6	15.0	91.5	10.6	43.3	0.84	3.37	203	210
PiAu 9-90	100	27.5	3.5	1.8	3.4	73.7	11.0	31.2	0.50	1.28	203	171
PiAu 51-11	100	24.3	3.5	2.0	18.0	40.7	18.1	60.7	0.75	2.54	242	246
M.9 NAKBT337	100	14.6	2.8	1.6	38.2	50.8	15.8	67.6	1.12	4.67	211	230
M.9 Pajam 2	100	13.9	2.6	1.5	48.8	72.5	10.4	48.9	0.74	3.53	200	218
M.26 EMLA	100	14.8	3.0	1.6	20.0	52.1	15.4	52.7	1.04	3.56	211	224
Est. HSD (*P = 0.05*)	---	12.5	1.0	0.4	32.8	56.2	10.7	34.8	0.56	1.38	58	44

Mean separation within columns by Tukey's HSD (P = 0.05).

lowest at the bottom. The dark bars are the cumulative yield efficiency. Presented this way, it is easy to see the standouts in each general size category. Among the small dwarfs, G.11 and CG.4003 are the most yeild efficient, and among the large dwarfs, G.935N and G.41N are the most yield efficient. Among the semidwarf trees, differences are more dramatic. Those on CG.3001, G.202N, and CG.4004 are much more yield efficient (double in many cases) than similarly sized trees on other rootstocks.

The largest fruit in 2017 were harvested from trees on B.7-3-150, G.202TC, B.64-194, and G.41TC, and the smallest fruit were from trees on B.71-7-22, G.935TC, and CG.5007 (Table 2). On average (2013-17) the largest fruit were harvested from trees on B.7-3-150 and B.67-5-32, and the smallest were harvested from those on PiAu 9-90 and B.71-7-22 (Table 2).

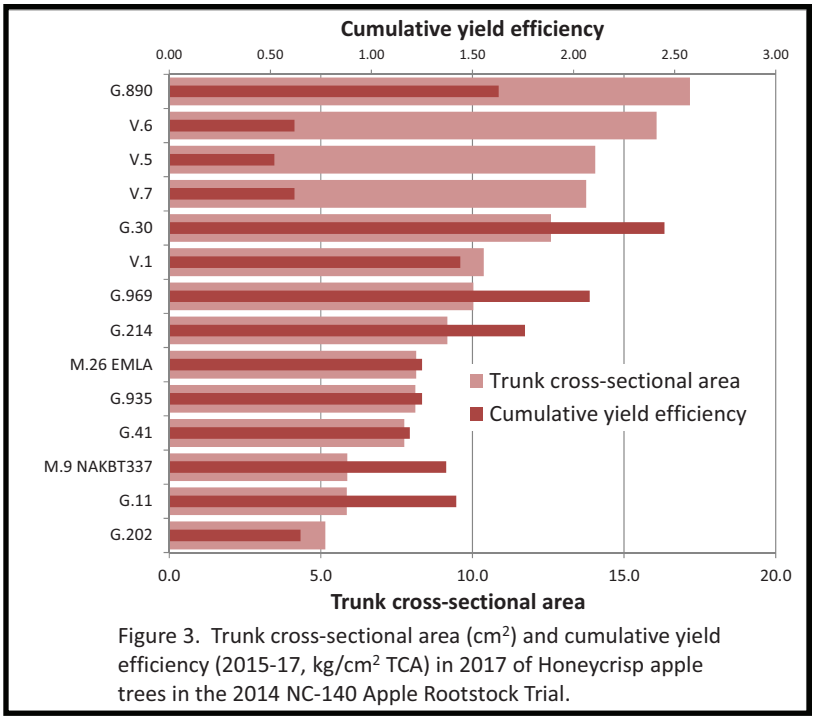

Figure 3. Trunk cross-sectional area (cm^2) and cumulative yield efficiency (2015-17, kg/cm^2 TCA) in 2017 of Honeycrisp apple trees in the 2014 NC-140 Apple Rootstock Trial.

2014 NC-140 Apple

As part of the 2014 NC-140 Apple Rootstock Trial, a planting of Honeycrisp on 13 rootstocks was established at the University of Massachusetts Cold Spring Orchard Research & Education Center. Rootstocks, including four from the Vineland series (V.1, V.5, V.6, and V.7), seven from the Geneva series (G.11, G.202, G.30, G.890, G.935, G.969, and CG.4214), and two standard rootstocks (M.26 EMLA and M.9 NAKBT337). The experimental design is a randomized complete block. Trees were trained and

Table 3. Tree and yield characteristics in 2017 of Honeycrisp apple trees in the 2014 NC-140 Apple Rootstock Trial at the UMass Cold Spring Orchard Research & Education Center, Belchertown, MA.

Rootstock	Trunk cross-sectional area (cm^2)	Root suckers (2017, no.)	Yield per tree (2017, kg)	Cumulative yield per tree (2015-17, kg)	Yield efficiency (2017, kg/cm^2)	Cumulative yield efficiency (2015-17, kg/cm^2)	Fruit weight (2017, g)
G.11	5.9 gh	0.5 c	2.7 cd	6.6 cd	0.44 bc	1.42 bcd	244 a
G.30	12.6 cd	7.4 a	10.7 a	22.2 a	0.89 ab	2.45 a	225 a
G.41	7.8 fgh	0.8 c	3.1 cd	6.6 cd	0.42 bc	1.19 bcd	250 a
G.202	5.2 h	0.4 c	1.7 d	2.6 d	0.35 c	0.65 cd	217 a
G.214	9.2 ef	6.5 a	5.6 bcd	11.3 bc	0.62 abc	1.76 ab	253 a
G.890	17.2 a	4.8 ab	7.3 abc	14.7 bc	0.45 bc	1.63 bcd	256 a
G.935	8.1 efg	3.1 bc	2.5 d	7.7 cd	0.32 c	1.25 bcd	242 a
G.969	10.0 ef	1.3 c	9.6 ab	16.2 ab	0.98 a	2.08 ab	243 a
V.1	10.4 bc	1.0 c	4.1 cd	11.0 bc	0.41 bc	1.44 bc	237 a
V.5	14.1 bc	1.1 c	3.2 cd	5.9 cd	0.23 c	0.52 d	243 a
V.6	16.1 ab	1.2 c	3.7 cd	7.8 cd	0.24 c	0.62 cd	244 a
V.7	13.8 bc	1.7 bc	1.7 d	6.1 cd	0.15 c	0.62 cd	264 a
M.9 NAKBT337	5.9 gh	2.4 bc	2.3 d	6.5 cd	0.39 c	1.37 bcd	231 a
M.26 EMLA	8.1 efg	1.9 bc	2.0 d	7.2 cd	0.27 c	1.25 bcd	260 a

Means separation within columns by Tukey's HSD (P = 0.05).

Table 4. Tree and yield characteristics in 2017 of Modi apple trees in the 2015 NC-140 Organic Apple Rootstock Trial at the Small Ones Farm, Amherst, MA.

Rootstock	Trunk cross-sectional area (cm^2)	Root suckers (2017, no.)	Yield per tree (2017, kg)	Yield efficiency (2017, kg/cm^2)	Fruit weight (2017, g)
G.11	3.89 cd	0.30 a	0.73 a	0.19 ab	146 a
G.16	1.53 f	0.47 a	0.12 a	0.07 b	127 ab
G.30	4.19 cd	0.42 a	1.07 a	0.29 ab	131 ab
G.41	5.12 bc	0.54 a	1.25 a	0.25 ab	120 ab
G.202	5.73 b	0.67 a	1.16 a	0.21 ab	133 ab
G.214	4.06 cd	0.00 a	0.72 a	0.19 ab	144 a
G.222	2.39 ef	0.27 a	0.80 a	0.33 ab	123 ab
G.890	7.60 a	0.17 a	1.03 a	0.14 b	137 ab
G.935	3.85 d	0.00 a	1.48 a	0.37 ab	109 b
G.969	3.97 cd	0.00 a	1.64 a	0.42 a	133 ab
M.9 NAKBT337	3.26 de	0.02 a	0.57 a	0.18 ab	111 ab

Means separation within columns by Tukey's HSD (P = 0.05).

Trees generally grew well in 2017 (4th leaf), however, bloom was deemed to be quite light and variable. No chemical or hand thinning was done. Tree size has remained consistent with previous years, i.e. G.890, V.6, V.5, and V.7 being the largest (possibly too large) trees (Table 3, Figure 4). Trees on G.202 are uncharacteristically small in this planting. In terms of fruit yield and yield efficiency, G.30 and G.969 are clear winners (Table 3, Figure 4). Unfortunately, G.30 also has the most root suckers (Table 3).

supported as Tall Spindles (spacing 1 x 4m) with trickle irrigation. Results from the 4th season are presented in Table 3 and Figure 3.

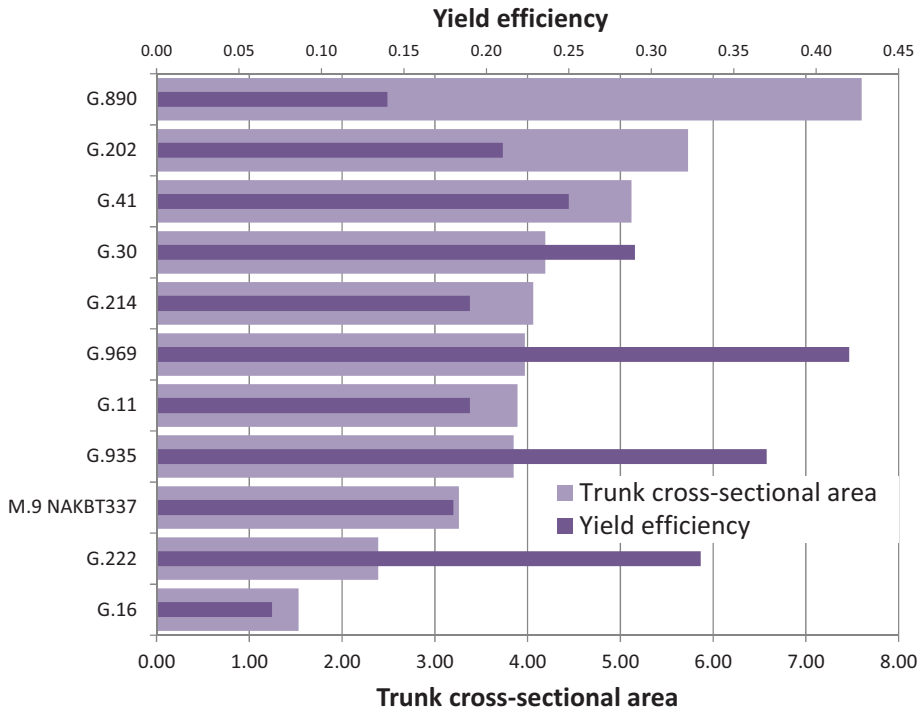

Figure 4. Trunk cross-sectional area (cm^2) and yield efficiency (kg/cm^2 TCA) in 2017 of Modi apple trees in the 2015 NC-140 Organic Apple Rootstock Trial.

2015 NC-140 Organic Apple

As part of the 2015 NC-140 Organic Apple Rootstock Trial, a planting of Modi on several Geneva rootstocks was planted at Small Ones Farm, Amherst, MA. Results from the 3rd growing season are presented in Table 4 and Figure 4.

Trees hung in there during the 2017 growing season; however, the disadvantages of an organic growing system are becoming apparent. More vigorous Geneva rootstocks, in this case G.890 and G.202, are the largest trees (Table 4, Figure 4). Fruit yield was generally on the low side and variable (Table 4), and the Modi apples were small with plenty of skin russet. In the 3rd leaf now it is really too early to draw many conclusions comparing these rootstocks in an organic orchard.

Unique Project Related Findings:

Prunus americana continues to be the most productive dwarfing peach rootstock in the trial, equaling the per-tree productivity of standard rootstocks and producing fruit of comparable size, but it produces so many root suckers that it may not be suitable for commercial plantings.

Accomplishments Related to Objective 1:

2009 NC-140 Peach: Largest trees were on Guardian; smallest trees were on Controller 5. Suckering was very high for P. americana.
2010 NC-140 Apple: Largest trees were on B.64-194; smallest trees were on B.71-7-22. Greatest cumulative yields were from trees on CG.3001; lowest were from trees on B.71-7-22. Most cumulatively yield efficient trees were on G.11, least for trees on PiAu 9-90. Largest fruit were from trees on B.7-3-150, smallest from trees on B.71-7-22.
2014 NC-140 Apple: Trees on V.5, V.6, V.7, and G.890 were largest, and those on G.202, M.9 NAKBT337, and G.11 were smallest. The most yield efficienty trees, cumulatively, were on G.30 and G.969.
2015 NC-140 Organic Apple: Trees on G.890 were the largest; trees on G.16 and G.222 were the smallest. The most yield efficient trees were on G.969, G.935, and G.222.

Impact Statements:

Planting of 150 acres of trees on dwarfing rootstock occurred during 2017 based on results of NC-140. On this acreage, pruning and harvest labor declined by 50%, fruit quality and size increased by 20%, profit increased by 50%, and because of reduced canopy volume, pesticide use declined by 70%.

Published Written Works:

Cowgill, WP Jr, WR Autio, EE Hoover, RP Marini, and PA Domoto. 2017. NC-140 Multi-State Research Project: Improving economic and environmental sustainability in tree-fruit production through changes in rootstock use. J. Amer. Pomological Soc. 71(1):34-46.
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http://www.ifruittree.org/Portals/0/CFT/2017_Fall/index.html

Scientific and Outreach Oral Presentations:

Autio, WR. Update on NC-140 trials in Massachusetts. Massachusetts Fruit Growers' Association Annual Meeting, February 8, 2017. Attendance: 80.

Fund Leveraging:

Autio, W, R Marini, J Cline, G Reighard, G Lang, and T Einhorn. 2017. NC-140 Rootstock Research Trial Coordinators. International Fruit Tree Association. $10,000.