ANNUAL REPORT TO NC-140

Massachusetts Agricultural Experiment Station

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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 grew well in their first eight 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 bolted trees, very little evidence of this damage persists. The planting includes eight replications in a randomized-complete-block design.

On February 14, 2016, temperatures dropped to -26C. This followed an abnormally warm December and was followed by -5C on April 4. The result was a complete loss of flower buds for 2016. Means from 2016 (8th growing season) are included in Table 1 and Figure 1.

At the end of the 2016 season, largest trees were on Guardian, Lovell, Atlas, Viking, and Krymsk 86, and smallest trees were on Controller 5, Krymsk 1, and *Prunus americana* (Table 1, Figure 1). Significantly more suckering occurred from trees on *P. americana* than from any other rootstock (Table 1).

No fruit were harversted in 2016, but on a cumulative basis (2011-15), yield was similar among most trees, except that yield from trees on Controller 5 was significantly

Table 1. Trunk size, root suckering, and canopy spread in 2016 of Redhaven peach trees in the 2009 NC-140 Peach Rootstock Trial at the UMass Cold Spring Orchard Research & Education Center, Belchertown, MA. Note that winter temperatures killed all flower buds for 2016, so cumulative yield and fruit size are based only on data through 2015. All values are least-squares means, adjusted for missing subclasses.

Rootstock	Trunk cross-sectional area (2016, cm^2)	Root suckers (no./tree, 2009-16)	Canopy spread (2016, cm)	Cumulative yield per tree (2011-15, kg)	Cumulative yield efficiency (2011-15, kg/cm^2)	Average fruit weight (2011-15, g)
Atlas	210 ab	0.1 b	464 ab	109 a	0.62 d	188 a
Brights Hybrid 5	178 b	0.0 b	441 abc	105 a	0.66 d	181 a
Controller 5	75 c	0.0 b	369 de	57 b	1.02 bc	172 a
Guardian	248 a	0.6 b	487 a	121 a	0.59 d	190 a
HBOK 10	182 b	0.5 b	422 bc	113 a	0.83 cd	182 a
HBOK 32	173 b	0.9 b	433 bc	116 a	0.81 cd	179 a
KV010-123	192 b	0.0 b	459 abc	117 a	0.78 cd	181 a
KV010-127	195 b	1.5 b	466 ab	119 a	0.71 cd	184 a
Krymsk 1	89 c	7.1 b	345 e	103 a	1.32 ab	186 a
Krymsk 86	207 ab	0.0 b	459 abc	100 a	0.59 d	180 a
Lovell	215 ab	0.0 b	449 abc	123 a	0.67 d	186 a
Mirobac	182 b	4.9 b	444 abc	108 a	0.74 cd	176 a
Prunus americana	99 c	187.0 a	412 cd	125 a	1.50 a	188 a
Penta	184 b	15.0 b	411 cd	94 a	0.60 d	186 a
Viking	202 ab	0.6 b	454 abc	120 a	0.72 cd	184 a

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

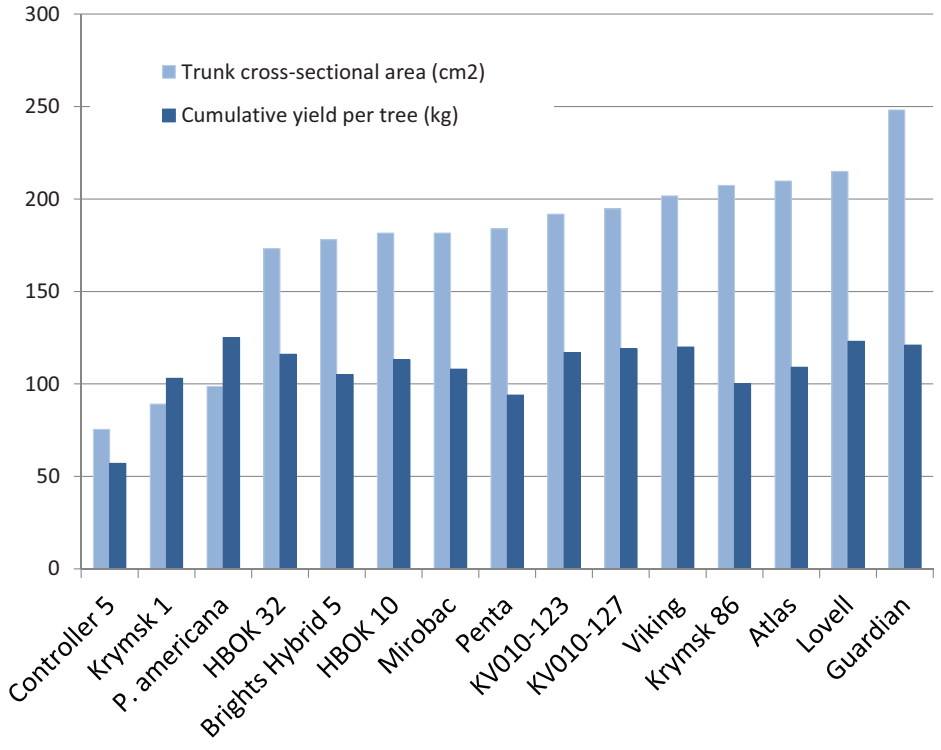

Figure 1. Trunk size and cumulative yield in 2016 of Redhaven peach trees in the 2009 NC-140 Peach Rootstock Trial.

University of Massachusetts Cold Spring Orchard Research & Education Center. 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. Means from 2016 (7th growing season) are included in Table 3 and Figure 3.

At the end of the 2016 growing season, largest trees were on B.64-194, B.70-6-8, B.67-5-32, and B.7-3-150, and smallest trees were on B.71-7-22 (Table 3, Figure 3). The greatest number of root suckers were produced (cumulatively, 2010-16) by CG.4214, G.202N, and M.9 lower than all others (Table 1, Figure 1). Cumulatively (2011-15), yield efficiency was greatest for trees on *P. americana* and lowest for trees on Brights Hybrid 5, Lovell, Atlas, Krymsk 86, Penta, and Guardian (Table 1). Fruit size on average (2011-15) was not different among rootstocks (Tables 1).

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

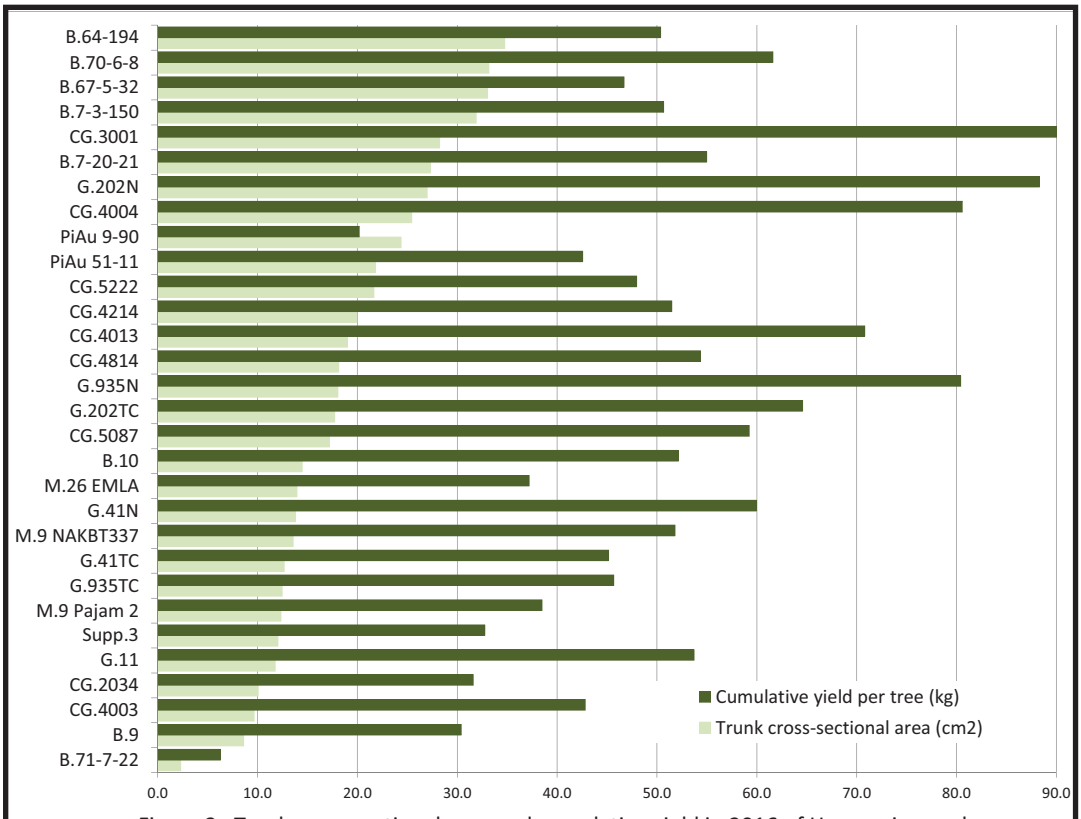

Figure 2. Trunk cross-sectional area and cumulative yield in 2016 of Honeycrisp apple trees on various rootstocks in the 2010 NC-140 Honeycrisp Apple Rootstock Trial.

Table 2. Trunk cross-sectional area, cumulative root sucker number, zonal chlorosis, yield per tree, yield efficiency, and fruit weight in 2016 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	Trunk cross-sectional area (2016, cm^2)	Cumulative root suckers (2010-16, no.)	Zonal chlorosis (2016, %)	Yield per tree (2016, kg)	Cumulative yield per tree (2013-16, kg)	Yield efficiency (2016, kg/cm^2 TCA)	Cumulative yield efficiency (2013-16, kg/cm^2 TCA)	Fruit weight (2016, g)	Average fruit weight (2013-16, g)
B.9	8.6	13.7	24.2	7.6	30.4	0.9	3.5	180	228
B.10	14.5	0.6	25.0	12.9	52.2	0.9	3.7	233	240
B.7-3-150	31.9	2.5	12.8	13.4	50.7	0.4	1.6	222	264
B.7-20-21	27.3	6.5	29.6	9.9	55.0	0.3	2.1	193	236
B.64-194	34.8	0.0	20.7	11.2	50.4	0.3	1.4	222	248
B.67-5-32	33.1	1.8	18.9	9.1	46.7	0.3	1.5	217	256
B.70-6-8	33.2	1.2	18.2	12.5	61.6	0.4	1.9	220	251
B.71-7-22	2.3	7.0	52.3	1.3	6.3	0.6	2.7	85	163
G.11	11.8	13.5	31.9	12.9	53.7	1.1	4.5	181	238
G.41N	13.8	0.5	23.4	15.0	60.0	1.0	4.2	210	246
G.41TC	12.7	14.3	26.3	13.8	45.2	1.0	3.5	214	244
G.202N	27.0	40.7	50.7	11.3	88.3	0.5	3.3	205	249
G.202TC	17.7	30.0	25.7	15.2	64.6	0.8	3.6	196	219
G.935N	18.1	22.4	67.5	14.2	80.4	0.8	4.4	202	230
G.935TC	12.5	28.6	89.5	12.3	45.7	0.9	3.5	201	223
CG.2034	10.1	0.1	53.7	8.2	31.6	0.7	3.0	157	212
CG.3001	28.2	3.8	23.8	19.8	106.5	0.7	3.8	223	245
CG.4003	9.7	2.1	23.0	9.0	42.8	0.9	4.3	143	195
CG.4004	25.5	16.0	32.5	18.0	80.6	0.7	3.2	233	250
CG.4013	19.0	28.5	40.2	19.3	70.8	0.9	3.5	191	221
CG.4214	19.9	53.7	67.1	12.6	51.5	0.6	2.6	213	238
CG.4814	18.1	30.3	80.6	9.5	54.4	0.5	3.1	200	219
CG.5087	17.2	8.6	69.8	16.7	59.3	1.0	3.3	160	213
CG.5222	21.7	26.1	64.2	10.5	48.0	0.5	2.2	199	223
Supp.3	12.1	8.7	85.0	7.7	32.8	0.6	2.7	165	211
PiAu 9-90	24.4	1.0	66.5	6.8	20.2	0.3	0.9	168	157
PiAu 51-11	21.8	11.4	39.9	8.5	42.6	0.4	2.0	208	247
M.9 NAKBT337	13.6	25.3	69.2	12.1	51.8	0.9	3.8	197	237
M.9 Pajam 2	12.4	36.9	61.7	8.6	38.5	0.7	3.3	187	224
M.26 EMLA	14.0	14.2	49.8	8.3	37.2	0.6	2.7	214	231
Est. HSD (*P = 0.05*)	9.1	22.6	45.2	7.8	25.7	0.4	1.1	64	41

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

Pajam 2 (Table 3).

In 2016, yield was greatest from trees on CG.3001, CG.4013, CG.4004, and CG.5087 and least from trees on B.71-7-22 and PiAu 9-90 (Table 3). Cumulatively (2013-16), greatest yields were harvested from trees on CG.3001, G.202N, CG.4004, and G.935N, and lowest yields were from trees on B.71-7-22 (Table 3). The most yield efficient trees in 2016 were on G.11, G.41N, G.41TC, and CG.5087. Cumulatively (2013-16), the most yield efficient trees were on G.11, G.935N, CG.4003, and G.41N. The least yield efficient trees in 2016 and cumulatively were on PiAu 9-90 (Table 3). The largest fruit in 2016 were harvested from trees on CG.4004 and B.10, and the smallest fruit were from trees on B.71-7-22, CG.4003, and CG.2034 (Table 3). On average (2013-16) the largest fruit were harvested from trees on B.7-3-150, B.67-5-32, and B.70-6-8, and the smallest were harvested from those on PiAu 9-90 and B.71-7-22 (Table 3).

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.4214, G.30, G.5890, G.935, and G.969), and two standard rootstocks (M.26 EMLA and M.9 NAKBT337). The experimental design is a randomized complete block. Trees were trained and supported as Tall Spindles (spacing 1 x 4m) with trickle irrigation. Results from the third season are presented in Table 3 and Figure 3.

Trees generally grew well in 2016 (3rd leaf), however, a significant freeze in early April, at early green tip, resulted in significant flower bud and spur damage, and thus reduced fruit yield. Generally, trees on the Vineland rootstocks were large, with V.6 being the largest, followed by V.7, V.5, and V.1. The Geneva rootstocks resulted in trees that were about what could be expected in terms of size, however, with the exception of G.202 which should be M.26 in size, but it was the smallest tree in the planting. Because of the bud freeze, yield from trees on all rootstocks was low. G.30 and G.214 resulted in more root suckers than most of the other rootstocks.

Table 3. Trunk cross-sectional area, yield, yield efficiency, and root suckering in 2016 of Honeycrisp apple trees in the 2014 Apple Rootstock planting at UMass Cold Spring Orchard Research & Education Center, Belchertown, MA.

Rootstock	Trunk cross-sectional area (cm^2)	Yield (kg)	Yield efficiency (kg/cm^2)	Root suckers per tree (no.)
V.1	8.2 d	1.8 abc	0.22 abc	0.8 c
V.5	10.2 c	1.6 abc	0.16 c	1.1 c
V.6	12.3 a	2.3 abc	0.19 bc	1.0 c
V.7	10.4 bc	3.5 ab	0.34 abc	2.2 bc
G.11	4.4 fg	2.1 abc	0.44 ab	0.1 c
G.30	9.9 c	2.8 abc	0.29 abc	5.6 a
G.41	5.5 ef	1.5 bc	0.27 abc	0.3 c
G.202	3.8 g	0.7 c	0.18 c	0.4 c
G.935	6.6 de	3.1 ab	0.45 a	0.9 c
G.969	7.5 d	3.0 abc	0.39 abc	0.6 c
CG.4214	6.6 de	2.2 abc	0.35 abc	4.6 ab
CG.5890	12.2 ab	3.9 a	0.31 abc	1.9 bc
M.9 NAKBT337	4.9 fg	1.9 abc	0.40 abc	2.1 bc
M.26 EMLA	6.6 de	2.3 abc	0.34 abc	0.4 c

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

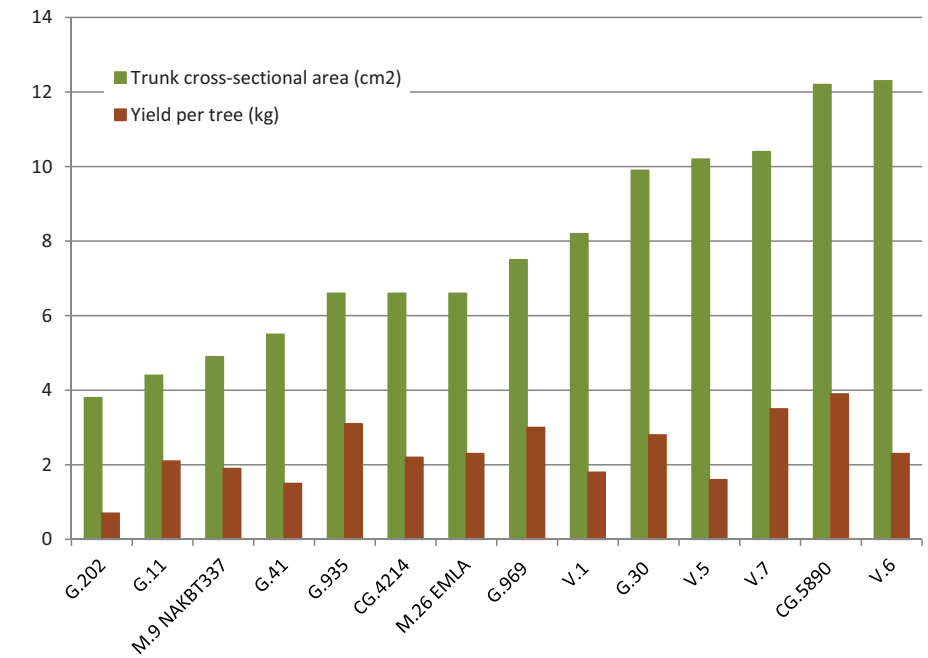

Figure 3. Trunk cross-sectional area and yield of Honeycrisp apple trees in the 2014 NC-140 Apple Rootstock Trial.

2015 NC-140 Organic Apple

As part of the 2015 NC-140 Organic Apple Roostock Trial, a planting of Modi on

several Geneva rootstocks was planted at Small Ones Farm, Amherst, MA. Results from the second season are presented in Table 4 and Figure 4.

Given the difficult nature of the 2016 growing season, including a bud freeze in early April which resulted in no fruiting, an ongoing drought (although these trees were irrigated), and the difficult nature of growing organically, the Modi' trees in this rootstock planting grew reasonably well. There were, however, some obviously small trees at the end of the growing season, most notably G.16 (in particular) and G.222. Note that these trees may have also been small at planting. An early and probably obvious conclusion might be that a more vigorous rootstock is highly desirable in an organic apple planting. Root suckering was minimal across the board.

Of note is the fact that twelve Liberty/G.935 trees were planted as pollinators, and most of those trees died in 2015, with one or two hanging on in 2016. It also looks like a few of the Modi/G.935 had discolored foliage and defoliated early, making one wonder if the Liberty and Modi scions are infected with virus and we are seeing an interaction with the virus-sensitive G.935 rootstock. This will need to be monitored closely in 2017.

Table 4. Trunk cross-sectional area in 2015 and 2016 of Modi apple trees in the 2015 Organic Apple Rootstock planting, Small Ones Farm, Amherst, MA.

Rootstock	Trunk cross-sectional area (2015, cm^2)	Trunk cross-sectional area (2016, cm^2)	Increase in trunk cross-sectional area (cm^2)	Increase in trunk cross-sectional area (%)
G.11	1.7 cd	2.5 ef	0.8	68
G.16	0.6 e	1.1 g	0.5	55
G.30	1.5 d	2.9 de	1.3	54
G.41	2.6 a	4.1 b	1.5	63
G.202	2.5 a	3.8 bc	1.3	66
G.214	1.5 d	2.7 de	1.2	56
G.222	0.8 e	1.7 fg	0.9	47
G.890	2.8 a	5.6 a	2.5	53
G.935	2.1 b	3.3 cd	1.2	64
G.969	1.8 bcd	3.0 de	1.2	60
M.9 NAKBT337	2.0 b	2.9 de	0.9	69

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

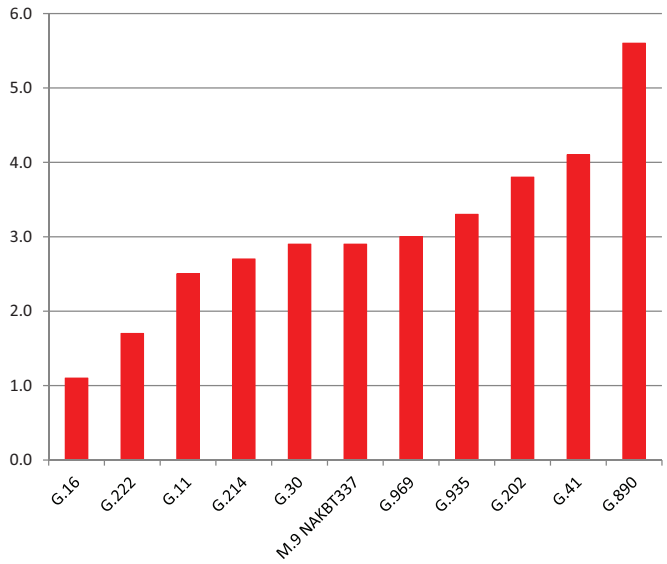

Figure 4. Trunk cross-sectional area of Modi trees on several rootstocks in the 2015 NC-140 Organic Apple Rootstock Trial.

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. Largest fruit were from trees on B.7-3-150.
2014 NC-140 Apple: Trees on V.6 and CG.5890 were largest, and those on G.202 and G.11 were smallest.
2015 NC-140 Organic Apple: Trees on G.890 were the largest; trees on G.16 and G.222 were the smallest.

Impact Statements:

Planting of 200 acres of trees on dwarfing rootstock occurred during 2016 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:

Marini, RP, WR Autio, B Black, J Cline, WP Cowgill Jr., RM Crassweller, C Hampson, MM Kushad, R Moran, M Parker, RL Perry, GL Reighard, T Robinson, and D Wolfe. 2016. Time required for classifying rootstock vigor in multi-location rootstock trials. Journal of the American Pomological Society 70(2):82-91. http://www.pubhort.org/aps/70/v70_n2_a4.htm

Autio, W, T Robinson, B Black, R Crassweller, E Fallahi, M Parker, R Parra Quezada, and D Wolfe. 2017. Budagovsky, Geneva, Pillnitz, and Malling apple rootstocks affect 'Fuji' performance over the first five years of the 2010 NC-140 Fuji Apple Rootstock Trial. Journal of the American Pomological Society 71(2): in press.

Autio, W, T Robinson, B Black, S Blatt, D Cochran, W Cowgill, C Hampson, E Hoover, G Lang, D Miller, I Minas, R Parra Quezada, and M Stasiak. 2017. Budagovsky, Geneva, Pillnitz, and Malling apple rootstocks affect 'Honeycrisp' performance over the first five years of the 2010 NC-140 Honeycrisp Apple Rootstock Trial. Journal of the American Pomological Society 71(2): in press.

Autio, WR, JS Krupa, JM Clements, and WP Cowgill Jr. 2016. Evaluation of peach rootstocks: 2009 NC-140 Peach Rootstock Trial through seven growing seasons. Fruit Notes 81(3):1-3. http://umassfruitnotes.com/v81n3/Cover813.html

Autio, WR, JS Krupa, JM Clements, and WP Cowgill Jr. 2016. Evaluation of peach rootstocks: 2009 NC-140 Peach Rootstock Trial through seven growing seasons. Horticultural News 96(3):1-3. http://horticulturalnews.org/96-3/Cover96-3.html

Scientific and Outreach Oral Presentations:

Autio, WR. Update and tour of the current NC-140 trials at the UMass Cold Spring Orchard. Massachusetts Fruit Growers' Association Annual Summer Meeting, July 13, 2016.

Fund Leveraging:

Autio, W, R Marini, J Cline, G Reighard, G Lang, and T Einhorn. 2016. NC-140 Rootstock Research Trial Coordinators. International Fruit Tree Association. $10,000.