



Massachusetts Agricultural Experiment Station

November 2021

Wesley Autio (leader), Jon Clements, Daniel Cooley, Duane Greene, Elizabeth Garofalo , and James Krupa

2014 NC-140 Apple Rootstock Trial

After two years of relatively light fruit set in this trial, 2021 produced admirable yields of Honeycrisp apples pretty much across the board, with most of the rootstocks producing a bushel of apples per tree. In terms of cumulative yield efficiency (2015-21) (Table 1 and Figure 1), trees on G. 30, G. 969, G.11, and M.9 NAKBT337 were superior. Trees on G.890 and G.30 produce too many root suckers. Fruit from trees on G.969 still seem to suffer from lack of red color,

that may be a result of too many apples per tree? ReTain was applied here in 2021 which also resulted in the delay in red color development. Overall, the Vineland rootstocks are underperforming compared to the Geneva rootstocks, and all but maybe V.1 and V.7 are too big a tree for the tall-spindle system. Powdery mildew, rosy apple aphid, and bitter rot were significant problems in 2021 and need to be better managed going forward.

Table 1. Tree and yield characteristics in 2021 of Honeycrisp apple trees in the 2014 NC-140 Apple Rootstock Trial at the UMass Cold Spring Orchard Research & Education Center, Belchertown, MA.

Rootstock	Survival (2014-21, %)	Trunk cross-sectional area (2021, cm ²)	Cumulative root suckers (2015-21, no./tree)	Yield per tree (2021, kg)	Cumulative yield per tree (2015-21, kg)	Yield efficiency (2021, kg/cm ² TCA)	Cumulative yield efficiency (2015-21, kg/cm ² TCA)	Fruit weight (2021, g)
V.1	100 a	20.3 cd	5.0 e	18.7 bcde	55.9 cde	0.95 b	2.85 cde	262 abc
V.5	100 a	27.7 ab	2.6 e	20.8 abcd	67.5 bc	0.79 b	2.51 e	286 a
V.6	100 a	31.3 ab	4.1 e	26.1 ab	75.5 ab	0.86 b	2.46 e	278 ab
V.7	100 a	25.6 bc	4.7 e	24.4 abc	65.9 bcd	1.03 ab	2.74 de	271 abc
G.11	100 a	12.4 efg	3.6 e	14.5 de	50.3 cdef	1.19 ab	4.01 ab	283 ab
G.30	100 a	25.5 bc	34.9 ab	23.2 abc	87.2 a	0.93 b	3.47 abcde	275 abc
G.41	90 a	16.1 def	7.1 de	16.1 cde	48.4 cdef	0.99 b	2.98 cde	276 abc
G.202	100 a	11.2 fg	2.9 e	13.0 e	33.9 f	1.14 ab	2.92 cde	264 abc
G.214	100 a	17.9 de	27.4 bc	18.7 bcde	58.0 bcde	1.04 ab	3.26 bcde	261 abc
G.890	100 a	33.2 a	42.0 a	26.9 a	91.5 a	0.82 b	2.79 de	287 a
G.935	100 a	14.8 defg	17.3 cd	16.5 cde	53.2 cde	1.13 ab	3.59 abcd	247 bc
G.969	90 a	20.0 cd	11.6 de	20.8 abcd	76.5 ab	1.04 ab	3.84 abc	264 abc
M.9 NAKBT337	100 a	9.9 g	9.5 de	14.0 de	42.8 ef	1.44 a	4.32 a	239 c
M.26 EMLA	100 a	16.2 def	11.4 de	17.0 cde	48.3 def	1.07 ab	3.06 bcde	252 abc

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

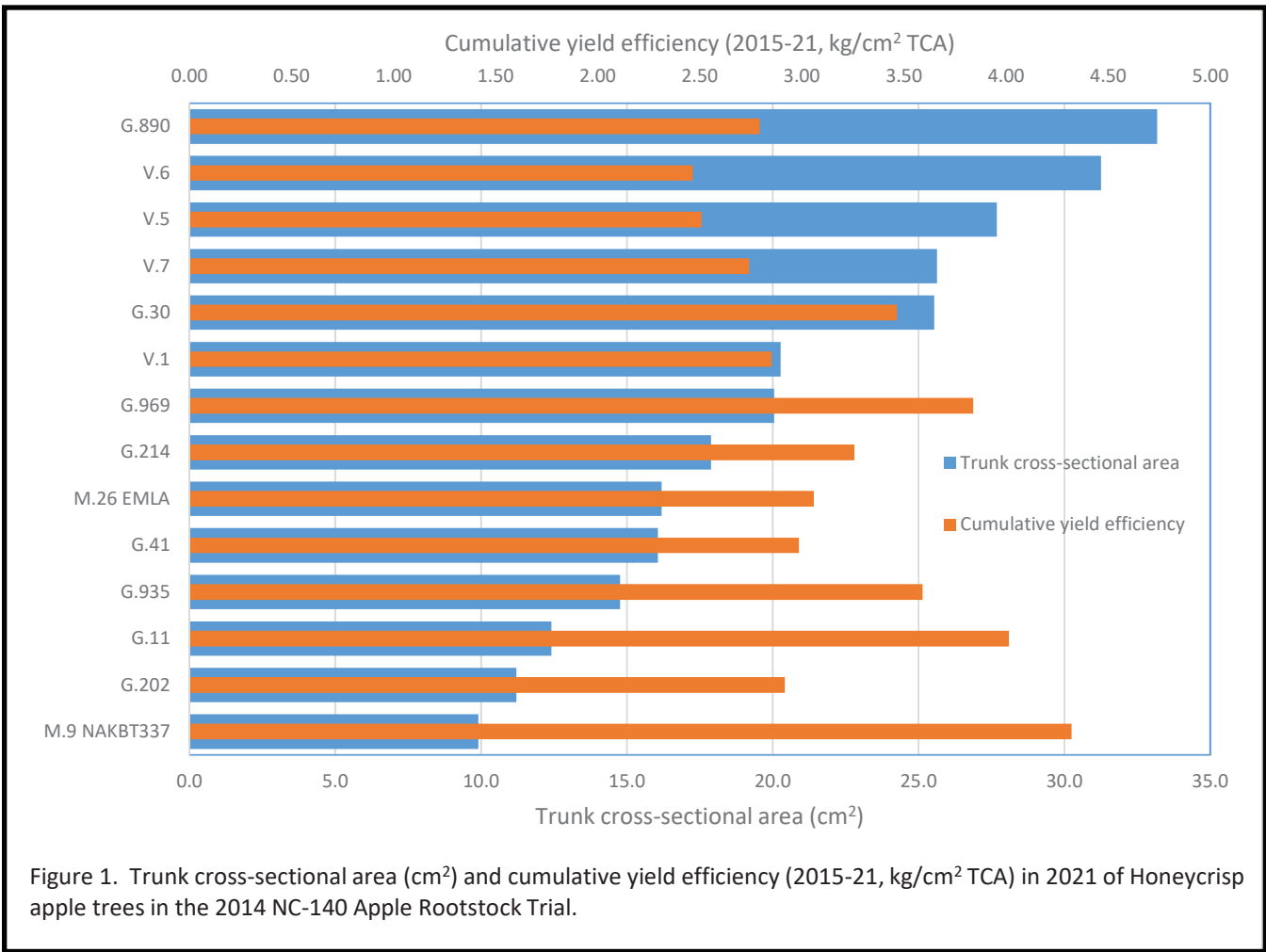


Figure 1. Trunk cross-sectional area (cm²) and cumulative yield efficiency (2015-21, kg/cm² TCA) in 2021 of Honeycrisp apple trees in the 2014 NC-140 Apple Rootstock Trial.

2015 NC-140 Organic Apple Rootstock Trial

This “organic” planting in a Certified Naturally Grown (<https://www.cngfarming.org/>) commercial orchard is still suffering. Several more trees succumbed in 2021 to vole damage (weed control is not good) or other unknown causes. Modi apples at harvest were generally small and malformed, although not as bad as in 2020. Overall tree vigor is

still weak with minimal shoot growth. As expected, rootstocks with more vigor (G.890, G.202, and G.214) have generally fared better than more dwarfing rootstocks (Table 2 and Figure 2). This planting is likely to be discontinued in 2022 as an NC-140 trial given its condition and the fact the orchard is currently for sale.

Table 2. Tree and yield characteristics in 2021 of Modi apple trees in the 2015 NC-140 Organic Apple Rootstock Trial at the Small Ones Farm, Amherst, MA. All values are least-squares means adjusted for missing data.

Rootstock	Survival (2015-21, %)	Trunk cross-sectional area (2021, cm ²)	Root suckers (2015-21, no./tree)	Yield per tree (2021, kg)	Cumulative yield per tree (2016-21, kg)	Yield efficiency (2021, kg/cm ²)	Cumulative yield efficiency (2016-21, kg/cm ²)	Fruit weight (2021, g)	Average fruit weight (2016-21, g)
G.11	50 ab	7.8 b	0.5 a	1.4 b	4.7 ab	0.18 a	0.62 a	91 a	89 a
G.16	14 b	3.0 b	2.3 a	0.7 b	2.4 ab	0.12 a	0.44 a	69 a	68 a
G.30	67 ab	10.4 b	3.6 a	2.9 ab	6.7 a	0.24 a	0.67 a	100 a	107 a
G.41	50 ab	9.2 b	6.9 a	1.9 ab	3.8 ab	0.18 a	0.40 a	94 a	88 a
G.202	83 a	11.2 b	6.4 a	2.7 ab	5.5 ab	0.23 a	0.50 a	105 a	105 a
G.214	75 ab	9.2 b	1.3 a	2.5 ab	5.9 ab	0.28 a	0.64 a	97 a	89 a
G.222	40 ab	5.8 b	2.9 a	1.3 b	3.2 ab	0.19 a	0.60 a	81 a	90 a
G.890	50 ab	17.9 a	2.4 a	5.0 a	8.9 a	0.30 a	0.52 a	105 a	96 a
G.935	17 b	8.9 b	1.5 a	2.5 ab	5.8 ab	0.26 a	0.66 a	137 a	103 a
G.969	75 ab	7.2 b	1.3 a	1.4 b	4.8 ab	0.18 a	0.68 a	87 a	87 a
M.9 NAKBT337	35 ab	5.1 b	0.2 a	0.2 b	0.4 b	0.08 a	0.26 a	83 a	105 a

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

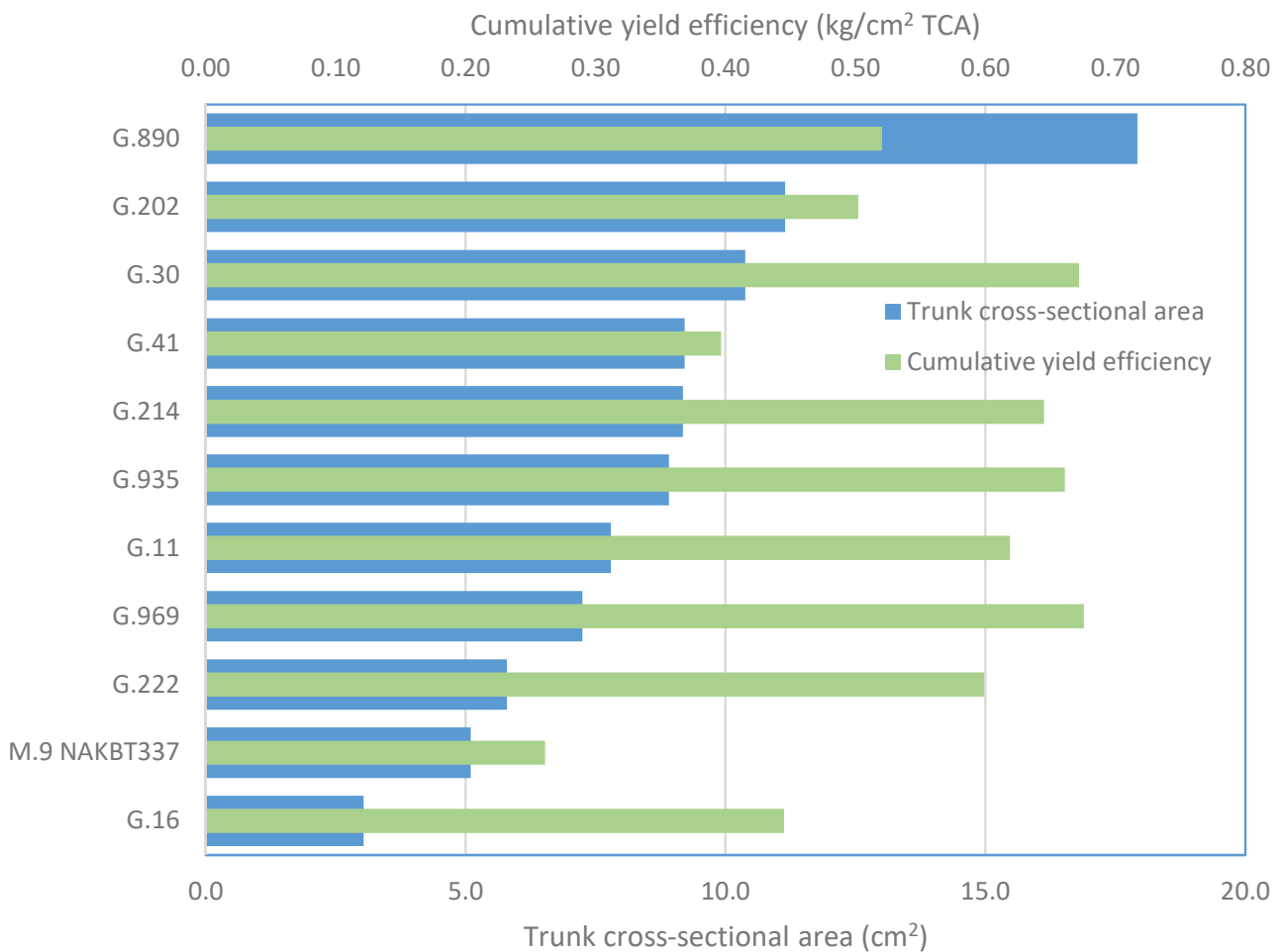


Figure 2. Trunk cross-sectional area (cm²) and cumulative yield efficiency (2017-21, kg/cm² TCA) in 2021 of Modi apple trees in the 2015 NC-140 Organic Apple Rootstock Trial.

Fruit Scout App

Trunk measurement estimates were made in late summer using the Fruit Scout app (<https://fruitscout.ai/>). A total of 133 trunks were measured in this trial using both the Fruit Scout app and using a tape measure and overall means compared using analysis of variance. Interestingly there was a highly significant difference ($P < 0.0001$) between mean trunk area estimates made with Fruit Scout (24.2 cm²) versus actual measurements of circumference made with a tape measure (20.1 cm²). The

two measurements were highly correlated, however ($r=0.943$, $P < 0.0001$). Fruit scout is estimating trunk cross-sectional area based on visualization of diameter (Figure 3), which could account for some of the difference, but also positioning of the cell phone when the picture was taken seemed to result in some larger discrepancies. Feedback to the Fruit Scout team was provided so they could improve their estimation of trunk size.



Figure 3. ARUco code/Fruit Scout App picture to measure trunk diameter as seen in TABLEAU.

Accomplishments Related to Objective 1:

2014 NC-140 Apple: Trees generally performed well in 2021 (eighth leaf). Survival has been good. Largest trees were on G.890, V.6, and V.5, and smallest were on G.935, G.11, G.202, and M.9 NAKBT337. Because of the measured tree size, it is clear that trees labeled as being on G.202 are actually on some other rootstock. Cumulatively (2015-21), the greatest yields per tree were from trees on G.890, G.30, G.969, and V.6, and the lowest were from those on G.202, M.9 NAKBT337, M.26 EMLA, G.41, and G.11. Cumulatively (2015-21), the most yield efficient trees were on M.9 NAKBT337, G.11, G.969, G.935, and G.30, and the least were on V.6, V.5, V.7, and G.890. In 2021, fruit size was largest from trees on G.890 and V.6 and smallest from trees on M.9 NAKBT337, but even the smallest fruit were 239g on average.

2015 NC-140 Organic Apple: Trees in this trial continue to be challenged and unproductive. After seven growing seasons, only 50% of the trees have survived, with the greatest loss of trees on G.16 and G.935. The best survival was observed for trees on G.202, G.214, and G.969. Largest trees were on G.890, and the smallest were on G.16. Cumulatively (2016-21), the greatest yields per tree were harvested from trees on G.890 and G.30, and the lowest were harvested from trees on M.9 NAKBT337. In 2021 and cumulatively (2016-21), trees on the various rootstocks were similarly yield efficient and carried fruit of similar size.

Impact Statements:

Planting of 150 acres of trees on dwarfing rootstock occurred during 2021 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:

Cline, J.A., W. Autio, J. Clements, W. Cowgill, R. Crassweller, T. Einhorn, E. Fallahi, P. Francescato, E. Hoover, G. Lang, J. Lordan, R. Moran, M. Muehlbauer, S. Musacchi, M. Stasiak, R. Parra Quezada, T. Robinson, S. Serra, S. Sherif, R. Wiepz, and J. Zandstra. 2021. Early performance of 'Honeycrisp' apple trees on several size-controlling rootstocks in the 2014 NC-140 Rootstock Trial. J. Amer. Pomol. Soc. 75:189-202.