2015 Progress Report – Evaluation of the Cornell-Geneva Apple Rootstocks and Other Promising Apple Rootstocks

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INTRODUCTION

A number of new apple rootstocks from the Cornell/USDA apple rootstock breeding project, located at Geneva, NY which are resistant to the bacterial disease fire blight *(Erwinia amylovora)* are rapidly becoming available. These rootstocks are also dwarfing, resistant to apple replant disease and productive (Fazio, et al., 2014; Kviklys, et al., 2014; Robinson, et al., 2014a and b). In this project, which is supported by the IFTA Research Foundation, we are continuing to test the field performance, disease resistance and nursery performance of elite Geneva® rootstocks and rootstocks from around the world.

MATERIALS AND METHODS

We have established a series of replicated field plots at the Geneva experiment station and on grower's farms across NY State. The plots have from 5-15 CG stocks with appropriate Malling controls. Several plots also include new rootstocks from around the world. With each of these trials we collect annual tree growth, yield, fruit size, tree survival and root sucker data. In this article we report results on 1 of the field trials and on new work on graft union strength as well as progress on commercialization.

RESULTS AND DISCUSSION

2010 Honeycrisp Apple Rootstock Trial. This objective of this experiment is to identify improved rootstocks for use with Honeycrisp, which is a weak growing cultivar. In many commercial orchards, which have been planted using B.9 or M.9, the trees have failed to adequately fill the space after 3 years resulting in reduced moderate levels of yield, which often carry over for several years. The results from our experiment after 5 years show that the most dwarfing stock in this trial was B.71722, which was too dwarfing for commercial use (Table 1). CG.2034 and B.9 were very dwarfed and probably also too dwarfing for commercial use with Honeycrisp. G.11, CG.4003, G.41TC and G.41N were slightly larger while Sup.3, M.9Pajam2, G.935TC, M.9T337, B.10, G41N and M.26 were all slightly larger than the G.11 group and similar in size. All of these stocks had sufficient vigor to fill the space of a 2.5 foot inrow spacing. A slightly larger group included only CG.4214, G.935N, CG.4013, CG.5202, CG.4004, CG.4814 CG.5087, G.202N, and G.202TC. These stocks had the proper vigor for an inrow spacing of 3 feet. The most vigorous stocks in this trial included B.67-532, CG.3001, B.73-150, PiAu51-11, B.64-194, B.70-68, B.72-021, and PiAu990 and were judged as not suitable rootstocks for high density Honeycrisp orchards. One stock (B.72-020) was significantly more vigorous than all other stocks.

The most yield efficient stocks were B.9 (which was excessively dwarfed) and CG.4003 followed by B.10, M.9T337, B.71722, (which was extremely dwarfed), G.11, G.4814, Sup.3 G.41N, G.935N, G935TC, G4214, G202TC, CG.5202, G.41TC, and CG5087. All other stocks had low yield efficiency.

Among the comparisons of rootstocks, which had a tissue culture origin verses rootstocks with a traditional stool bed origin, G.41TC and G.41N were similar in size and had similar yield efficiency. G.935TC was smaller than G.935N and also had similar yield efficiency. G.202TC was slightly smaller than G.202N but had similar yield efficiency. Thus it appears the use of tissue culture did not largely affect tree size or yield efficiency.

Fruit size was large with almost all stocks. Those which had smaller fruit size were CG.4003, B.71-722 and CG.202TC.

Tree survival was poorest (significantly less than 100%) with B.71-722 and G.41TC.

The effect of rootstock genotype on biennial bearing was evaluated by calculating the biennial bearing index for each stock for the first two cropping years (years three through four) and the next two cropping years (years four through five) (Table 2). This index has a scale from 0 to 1. A low index value (i.e. below 0.5) indicates less biennial bearing while and high index

value (i.e. higher than 0.5) indicates more biennial bearing. Some rootstocks, which had a low biennial bearing index in the first two years, had a high index in the next two years. A few rootstocks had a low biennial bearing index for both cycles, which included B.10, G.202N, CG.4003, CG.4814, G.935TC.

To select the best rootstocks to use with Honeycrisp we calculated the cumulative yield per hectare for each of the rootstocks assuming a spacing of 3X12 ft. (1210 trees/acre). The rootstock with the highest cumulative yield was G.4814, followed by CG.3001, B.10, CG.5087, G.202, G.5202, G.214 and CG4004 (Fig. 1). These data show that with Honeycrisp the medium vigor rootstocks had higher cumulative yield than the fully dwarfing rootstocks like B.9, M.9, G.11 and G.41. These fully dwarfing rootstocks need to be planted in less than 3 ft. inrow spacing to optimize their production. Data from this experiment is preliminary and conclusions would be better after 10 years of production. Nevertheless it is useful to compare the performance of a rootstock like B.9 (which is a good rootstock but does not have enough vigor with Honeycrisp) to G.814 which was able to fill the space of a 3X12 spacing in the first 3 years. G.814 produced a cumulative152 t/ha over the first 5 years while B.9 produced a cumulative 77 t/ha. This is a difference of 75 t/ha. If you assign a price of $0.85/lb for the fruit this would equate to an extra $56,850/acre if a grower planted G.814 versus B.9. This result illustrates the huge impact that identifying the best rootstock for each variety in each location has on the income farmers receive over the first 5 years. We have previously suggested that growers seek to produce a cumulative 150 t/ha (3300 bu/acre) over the first 5 years of any new orchard. This has been difficult to do with Honeycrisp because it grows slow. This experiment shows that with the right rootstock such levels of production are possible.

Table 1

Stock	TCA 2014 (cm^2)	Tree Survival (%)	Cum. Fruit No.	Cum. Yield (kg/tree)	Cum. Yield Eff.	Av. Fruit Size (g)	Av. Crop Load	Cum Root Suckers
Bud71722	2.5	67	42.5	8.0	3.18	192.4	7.1	2.8
CG2034	6.0	80	68.0	17.1	2.85	278.6	4.9	2.8
Bud9	6.3	100	110.3	24.3	3.94	237.3	7.6	3.3
CG4003	9.1	100	181.0	35.0	3.87	198.9	8.3	0.4
G11	10.2	100	134.1	32.3	3.13	258.6	6.2	2.4
G41TC	10.2	67	111.0	26.9	2.62	249.0	4.3	1.5
M9T337	11.8	100	144.1	36.3	3.27	256.7	5.7	6.8
M9Pajam2	12.0	100	131.3	30.2	2.44	244.9	4.7	22.3
Bud10	12.2	89	183.8	42.9	3.63	247.2	6.6	2.1
G41N	12.2	91	137.2	33.7	2.83	263.3	5.6	1.5
M26	12.2	88	122.0	28.8	2.39	252.9	4.6	5.8
Sup3	12.2	83	151.0	35.6	2.94	249.2	5.9	3.7
G935TC	12.4	100	138.0	33.9	2.81	262.9	5.0	6.0
CG4214	14.0	100	154.6	38.4	2.78	262.9	5.0	11.0
G935N	14.6	80	165.3	36.5	2.49	243.5	4.9	2.6
CG5202	14.7	86	167.3	39.0	2.71	241.4	4.9	17.7
CG4814	15.4	88	197.4	47.9	3.13	256.8	5.3	5.7
CG5087	16.0	100	195.7	42.2	2.63	242.7	5.5	10.7
G202TC	16.2	100	174.6	38.8	2.78	234.9	5.5	5.6
CG4004	17.6	80	165.3	37.5	2.21	250.7	4.7	10.3
CG4013	17.8	100	104.8	23.0	1.42	268.6	3.4	9.8
G202N	18.1	80	159.0	37.5	2.62	253.8	5.2	7.5
Bud67532	18.4	100	118.5	27.4	1.53	246.6	3.6	1.1
CG3001	18.4	100	175.3	45.7	2.47	274.4	4.2	2.7
Piau5111	18.6	100	150.6	37.2	2.02	263.6	3.6	1.8
Bud73150	21.7	100	149.0	39.3	1.84	274.2	3.6	1.5
Bud72021	22.4	100	148.3	37.1	1.69	266.6	3.4	1.4
Bud64194	22.8	100	141.4	36.3	1.62	263.6	3.3	0.3
Bud7068	23.0	100	151.5	38.9	1.73	266.9	3.6	0.8
Piau990	23.4	100	120.6	26.0	1.17	232.2	2.6	2.4
Bud72020	35.9	100	81.1	21.3	0.60	277.5	1.1	10.0
LSD P≤0.05	4.3	29	45.6	10.8	0.90	30.6	1.8	7.7

Rootstocks ranked by Trunk Cross-sectional Area.

TABLE 1 – CUMULATIVE PERFORMANCE OF HONEYCRISP APPLE TREES ON 31 ROOTSTOCKS AT GENEVA, NY OVER THE FIRST FIVE YEARS.

Graft Union Strength of Geneva Rootstocks. We have received several reports of trees breaking in the nursery with G.41 and with G.935 when grafted with some brittle varieties. We have previously conducted some research on this problem and have begun new research projects in 2014 in collaboration with Brent Black at Utah State University to evaluate graft union strength with his graduate student Stuart Adams. In 2014 we evaluated the method of grafting (chip bud vs. whip and tongue graft vs. machine V graft). The graft union strength has been evaluated on G.41, G.935, and M.9 with several cultivars at three times during the season (June, August and October). We also evaluated several plant growth regulators, which could be sprayed in the nursery to stimulate stronger graft unions. This research is not yet ready for publication but it is very promising. Nevertheless it seems clear with some varieties like Honeycrisp and Envy, G.41 had a weaker union than M.9Nic29.

We have learned from previous work that different rootstock genotypes have different graft union strength. In 2005 we broke graft unions of a range of Geneva rootstocks with Gala as the scion at the end of the season in the nursery. The strongest unions were twice as strong as the weakest

Table 2

Stock	Biennial Bearing Index (2012-2013)	Biennial Bearing Index (2013-3014)	Mean Biennial Bearing Index
Bud10	0.25	0.43	0.34
G202N	0.30	0.43	0.36
CG4003	0.38	0.41	0.40
CG4814	0.39	0.48	0.43
G935TC	0.37	0.50	0.44
Piau5111	0.45	0.42	0.44
CG5202	0.37	0.51	0.44
G202TC	0.39	0.49	0.44
Bud7068	0.30	0.60	0.45
G41TC	0.57	0.35	0.46
Bud73150	0.34	0.59	0.46
Sup3	0.33	0.62	0.47
Bud64194	0.41	0.55	0.48
M9T337	0.38	0.58	0.48
Bud9	0.34	0.64	0.49
CG2034	0.41	0.57	0.49
CG4214	0.49	0.53	0.51
CG3001	0.46	0.57	0.51
Bud72021	0.40	0.64	0.52
Bud71722	0.42	0.64	0.53
G11	0.48	0.61	0.55
G41N	0.36	0.74	0.55
M9Pajam2	0.52	0.71	0.62
Bud67532	0.47	0.78	0.63
Bud72020	0.69	0.62	0.66
M26	0.66	0.66	0.66
Piau990	0.60	0.81	0.71
CG5087	0.67	0.74	0.71
G935N	0.70	0.80	0.75
CG4004	0.64	0.87	0.75
CG4013	0.61	0.93	0.77
LSD P≤0.05	0.32	0.37	0.30

Rootstocks ranked by Trunk Cross-sectional Area.

TABLE 2 – BIENNIAL BEARING OF HONEYCRISP APPLE TREES ON 31 ROOTSTOCK AT GENEVA, NY OVER THE FIRST FIVE YEARS.

unions and were with CG.6589, CG.8534 and CG4002, all of which are vigorous stocks (Fig. 2). The weakest graft unions were with CG.6006. Among released Geneva rootstocks the strongest unions were with G.16 followed by G.11, G.210, G.30 and M.9. These were followed by G.214, G.890 and G.969. Unfortunately G.41 and G.935 were not included in this trial.

Figure 1

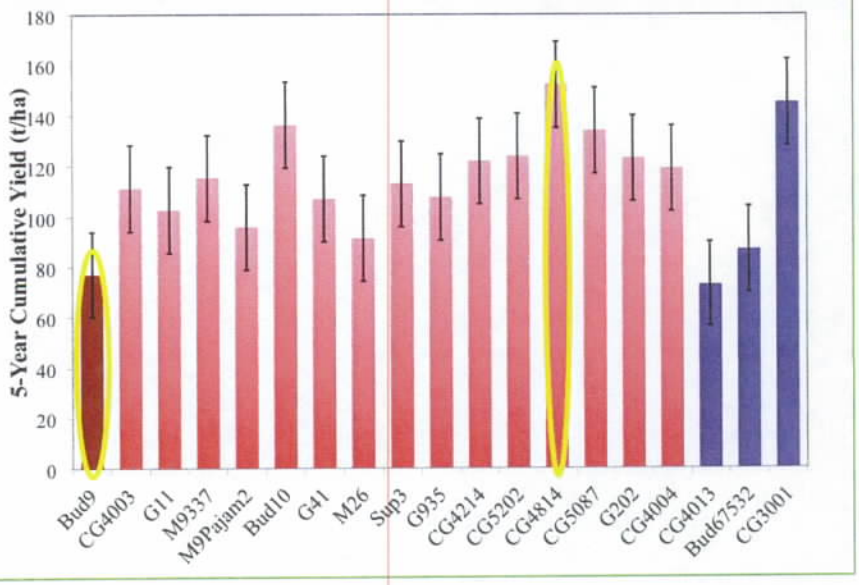

FIGURE 1 – CUMULATIVE YIELD PER HA OF HONEYCRISP APPLE TREES ON 19 ROOTSTOCKS AT GENEVA, NY OVER THE FIRST FIVE YEARS.

We have learned from previous work that different scion varieties have different graft union strength. In 2005 we compared the graft union strength of 20 cultivars grafted on G.30. Some cultivars had graft union strengths more than twice as strong as other cultivars (Fig. 3). Northern Spy, Fuji, Golden Delicious, Granny Smith and Idared had the strongest graft unions while Gala had an intermediate strength and James Grieve had the weakest graft unions. Unfortunately some of the newer varieties were not included in this study.

In a separate trial with only G.30 we plotted graft union strength over time and found that graft union strength is low in the nursery and increases rapidly in the first few years in the orchard (Fig. 4). After year four, graft union strength increases more slowly but reaches a high level by year 10 even with G.30, which has a brittle union.

These previous research projects indicate that traditional scion cultivars like McIntosh, Delicious, Empire and Fuji the graft union strength of G.41 and G.935 is good. With Gala the graft union strength is intermediate while with Honeycrisp and Envy the graft union strength is lower. When growers plant G.41 and G.935 with scions that have a weak graft union they should use care when planting the trees and they should immediately attach the trees to a trellis. We suggest two-three attachment points of the tree to the trellis (trunk, and lateral branches). Some of the new work we are doing with the application of plant growth regulators in the nursery to strengthen the graft union with weak scion cultivars is promising and we expect to have some recommendations for nurserymen in one year.

Release of New Apple Rootstocks. In 2014 the Geneva apple rootstock program released one new rootstock, G.814. This rootstock has been tested as CG4814. It is semi-dwarfing (about M.26 size). It was evaluated in the 1999 NC-140 McIntosh semi dwarf-trial where it was the most efficient semi-dwarfing stock. It has also shown good results with Honeycrisp (see data in this article). It has been trialed in a large scale WA state trial, which led to the decision to release this stock at the request of some nurseries for use with Gala.

Propagation of Apple Rootstocks. The propagation of several Geneva rootstocks has been improved significantly by the use of tissue culture plants as mother plants for stool beds, especially with G.41. This has resulted in a mini-boom of planting of Geneva 41 stool beds. We estimate that 150,000 feet of stool beds of G.11 and G.41 and about 50,000 feet of G.935 have been planted. This has resulted in a production of 1.5 million liners of G.11 in 2014 and 2.5 million liners of G.41 and 0.5 million liners of G.935.

Cornell had signed licenses with several additional rootstock producers in 2014. Licensed rootstock producers of Geneva® rootstocks are: Willow Drive Nursery, Willamette Nursery, Treco Nursery, Kit Johnston Farms, Copenhaven Nursery, Cameron Nursery, Gold Crown Nursery, KCK Farms, VanWell Nursery, Helios Nursery, ProTree Nursery, North American Plants, Mori Nursery, Ontario, Viveros Sacramento, Chihuahua and Viveros Casas Grandes, Chihuahua.

This winter (2014/2015) the U.S., Canadian and Mexican stool bed producers have harvested a total to ~4 million Geneva liners this past fall and winter. These liners will result in finished trees for growers in the spring of 2016 and 2017. Apple growers in the U.S., Mexico and Canada will now be able to begin utilizing these improved rootstocks in their orchards.

SUMMARY

With productive rootstocks, the importance of proper training and pruning cannot be overemphasized. If mismanaged, trees can quickly become imbalanced, producing small, poor quality fruit. However, when properly managed, all of these precocious rootstocks can provide early high yields of premium quality fruit. This research helps to identify the best combinations of variety and training system for a number of important, precocious rootstocks.

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Figure 2

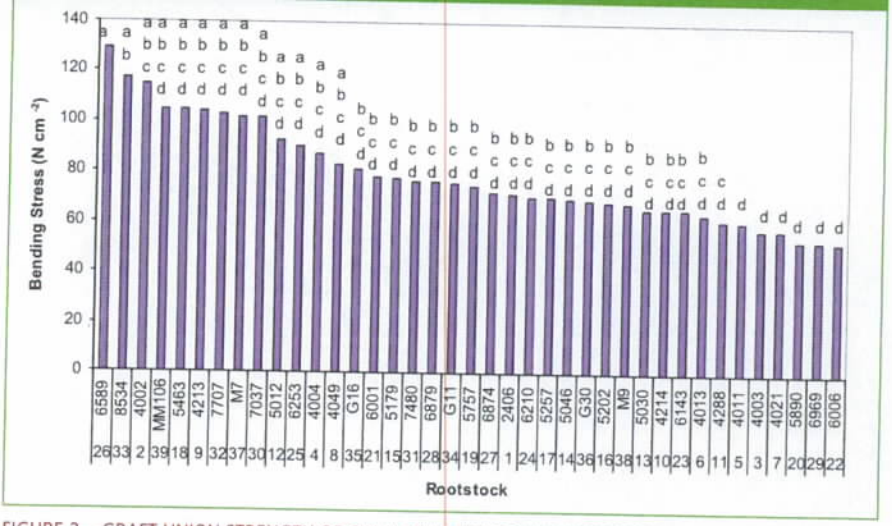

FIGURE 2 – GRAFT UNION STRENGTH OF GALA APPLE TREES ON 39 ROOTSTOCKS AT THE END OF THE GROWING SEASON IN THE NURSERY AT GENEVA, NY.

Figure 3

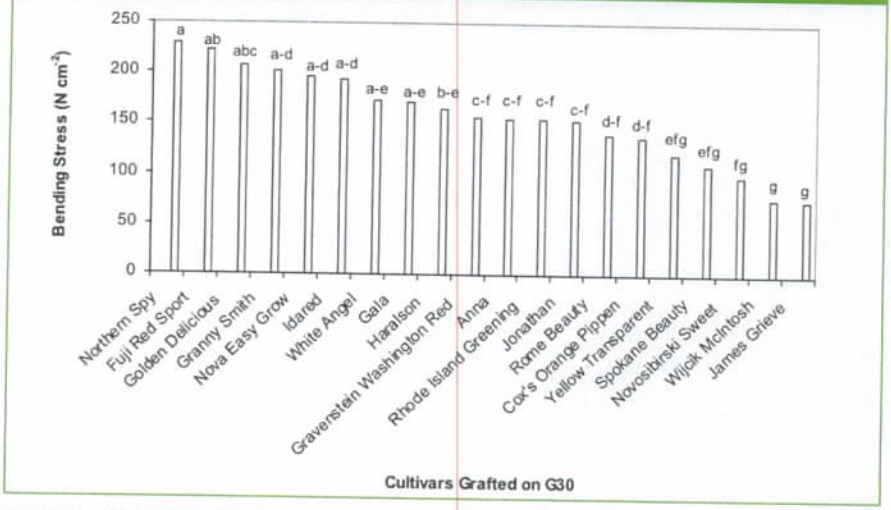

FIGURE 3 – GRAFT UNION STRENGTH OF 20 APPLE CULTIVARS ON G.30 ROOTSTOCK AT THE END OF THE GROWING SEASON IN THE NURSERY AT GENEVA, NY.

Figure 4

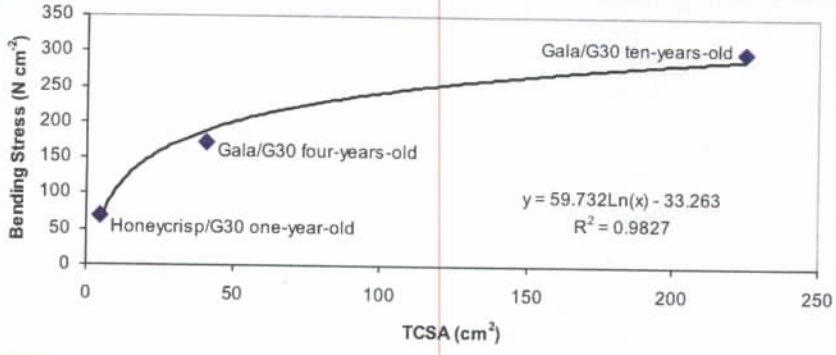

FIGURE 4 – CHANGE IN GRAFT UNION STRENGTH OF GALA AND HONEYCRISP APPLE TREES ON G.30 ROOTSTOCK AT THE END OF YEAR ONE, YEAR FOUR AND YEAR 10.