Characteristics and Performance of Four New Apple Rootstocks from the Cornell-USDA Apple Rootstock Breeding Program

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Abstract

In 2010, the Cornell-USDA apple rootstock breeding program at Geneva, NY released 4 new apple rootstocks (Geneva® 210, Geneva® 214, Geneva® 890 and Geneva® 969). G.210 is a semi-dwarfing rootstock with vigor similar to M.7, with high productivity similar to M.9 and resistance to fire blight, *Phytophthora* root rot, and woolly apple aphid. It has also shown tolerance to apple replant disease in field trials in New York and Washington. It is not free standing and requires a trellis for supporting the trees, which can lean under wet soils conditions. G.214 a fully dwarfing rootstock with vigor similar to M.9 with very high productivity and resistance to fire blight, *Phytophthora* root rot, and woolly apple aphid. It is easy to propagate in stoolbeds has shown tolerance to apple replant disease in field trials in New York and Washington. It is not free standing and requires a trellis. G.890 is a semi-dwarf rootstock with vigor similar to MM.111. It has high productivity (similar to M.26) and resistance to fire blight, *Phytophthora* root rot, and woolly apple aphid. It is easy to propagate in stoolbeds and is free standing in the orchard. G.969 is a semi-dwarfing rootstock with vigor similar to M.26 with very high productivity and resistance to fire blight, *Phytophthora* root rot, and woolly apple aphid. It is easy to propagate in stoolbeds. It is free standing in the orchard.

INTRODUCTION

For many apple growers in North America, the bacterial disease fire blight is a serious threat to dwarf apple orchards. Similarly apple replant disease limits tree growth and economic performance of many new high-density orchards. The Cornell University/ USDA apple rootstock breeding project, located at Geneva NY, has developed rootstock genotypes which are resistant to fire blight (*Erwinia amylovora*) and crown rot (*Phytophthora* spp.) (Cummins and Aldwinckle, 1983; Norelli et al., 2003; Russo et al., 2007). Some have been shown to have tolerance to apple replant disease (Auvil et al., 2010; Isutsa and Merwin, 2000; Robinson and Hoying, 2005). In 2010, we released four new apple rootstocks: Geneva® 210, Geneva® 214, Geneva® 890 and Geneva® 969. They have a range in vigor from M.9 size to MM.106 size.

MATERIALS AND METHODS

In 1975 and 1976, Dr. James Cummins and Dr. Herbert Aldwinckle of Cornell University crossed Ottawa 3 apple rootstock with Robusta 5 (a cold hardy and disease resistant selection of *Malus robusta*). Progeny from these crosses underwent rigorous greenhouse screening procedures at the small seedling stage to select for tolerance to fire blight and crown rot. When seedlings were about 2.5 cm tall they were inoculated via

flooding of the roots with a mixture of isolates of the fungus *Phytophthora cactorum*. Surviving seedlings were inoculated via injection to the shoot tip with fire blight bacteria (*Erwinia amylovora*). Surviving genotypes were then tested for propagation characteristics in the nursery, and productivity and dwarfing at the New York State Agricultural Experiment Station in Geneva, New York. Since 1991, the elite selections from these crosses have been tested in field trials at various locations by Robinson et al. (2003, 2005, 2011). Four elite selections were named in 2010.

In 2001, a replicated field trials of 7 Geneva® named and un-named elite rootstocks and 2 Malling rootstocks (M.7, and M.26), was planted at Wolcott, NY (Western part of State) using 'Golden Delicious' as the scion cultivar. The plot was laid out as randomized complete block experiment with 5 replications and with each block containing 3-5 individual trees of each rootstock. All of the plant material was grown in a common nursery in Geneva, NY. The trees were planted as unbranched whips at a spacing of (1.8 m x 4.5 m) and were headed at 1m after planting.

In 2004, a second replicated field trial of 8 Geneva® named and un-named elite rootstocks and 3 Malling rootstocks (M.9, M.7 and MM.106) and 1 Budgovsky stock (B.9) as controls was planted at Hilton, NY (Western part of state) using 'Honeycrisp' as the scion cultivar. The plot was laid out as randomized complete block experiment with 5 replications and with each block containing 2 individual trees of each rootstock. All of the plant material was grown in a common nursery in Geneva, NY. The trees were planted as unbranched whips at a spacing of (2.4 m x 4.8m) and were headed at 1 m after planting.

In 2005, a third replicated field trial of 8 Geneva® named and un-named elite rootstocks and 3 Malling rootstocks (M.27, M.9, M.26, M.7 and MM.106) and 1 Budgovsky stock (B.118) as controls was planted at Marlboro, NY (Eastern part of state) using 'Fuji' as the scion cultivar. The plot was laid out as randomized complete block experiment with 5 replications and with each block containing 1-2 individual trees of each rootstock. All of the plant material was grown in a common nursery in Geneva, NY. The trees were planted as unbranched whips at a spacing of (2.4 m x 4.8 m) and were headed at 1 m after planting.

With each of the three field trials, trees were managed with the vertical axis tree training system and fertilized annually with nitrogen and potassium according to local recommendations. Trees were supported with a single wire trellis and a metal tube tree stake. Tree survival, number of root suckers and trunk circumference at 30 cm above the graft union were measured annually in November. Fruit number and yield were recorded annually at harvest and fruit size (g) was calculated as the ratio of fruit yield divided by the number of fruit per tree. Cumulative yield efficiency was calculated by dividing cumulative yield by final trunk cross-sectional area. In the second experiment the biennial bearing tendency of each rootstock was assessed by calculating an alternate bearing index (ABI) for each two years of yield data using the formula: ABI = Absolute Value of (Fruit Number Year 2-Fruit Number Year 1) divided by the Sum of (Fruit Number Year 2+Fruit Number Year 1). This index gives values ranging from 0 to 1 with 0=no biennial bearing and 1=complete biennial bearing. Data were analyzed by ANOVA using SAS statistical analysis software (SAS Institute, Cary, NC, USA). Crop load was used as covariate to compare fruit sizes independent of crop load. Significant differences among means were determined by Least Significant Difference test.

RESULTS

Experiment 1

After 10 years, tree size of 'Golden Delicious' was greatest on G.890 rootstock followed in descending order by G.969, M.7, CG.5087, G.214, G.41, M.26 and G.11 (Fig. 1). Cumulative yield efficiency was greatest for G.41 followed by G.11, CG.5087, G.969, G.890, G.214, M.26 and M.7. All rootstocks had greater than 90% survival (data not shown).

Experiment 2

After 7 years, tree size of 'Honeycrisp was greatest on MM.106 rootstock followed in descending order by M.7, G.890, G.222, G.30, G.935, G.969, G.16, M.9, G.214, B.9 and G.11 (Fig. 2). Cumulative yield efficiency was greatest for B.9 followed by G.969, G.30, G.214, G.935, M.9, G.890, G.11, G.222, MM.106 and M.7. All rootstocks had greater than 90% survival (data not shown). Biennial bearing tendency was lowest for trees on G.222 followed by G.969, G.935, G.30, G.890, M.9, G.214, MM.106, B.9, G.16, M.7, and G.11 (Fig. 3).

Experiment 3

After 4 years, tree size of 'Fuji' was greatest on G.890 rootstock followed in descending order by B.118, G.210, M.7, MM.106, G.935, G.222, CG.5087, G.969, M.26, G.214, M.9, G.11 and M.27 (Fig. 4). Cumulative yield efficiency was greatest for G.969 followed by CG.5087, G.935, G.214, G.222, G.11, M.9, G.890, M.27, M.26, G.210, MM.106, B.118 and M.7. All rootstocks had greater than 90% survival (data not shown).

DISCUSSION

Geneva® 214

Geneva® 214 is derived from a cross made in 1975 between Ottawa 3 and Robusta 5. G.214 was evaluated as CG.4214. Field trials in New York State indicate that G.214 is a dwarfing rootstock similar in size to M.26 with 'Golden Delicious' (Fig. 1) and 'Fuji' (Fig. 2); however, with 'Honeycrisp' (Fig. 3) it was similar in size to M.9. In all three field trials, G.214 was highly yield efficient, similar to M.9 and M.26. With Fuji it was significantly more yield efficient than M.9. Other experiments with this rootstock have confirmed it is resistant to fire blight, *Phytophthora* root rot, and woolly apple aphid. Nursery trials at Geneva, NY and in Washington State have shown that it is easy to propagate in stoolbeds. G.214 is similar in size to G.41 but is easier to propagate in the stoolbed. Field trials in Washington State have shown that G.214 like G.41 has tolerance to apple replant disease (Auvil et al., 2011). It is not free standing and requires a trellis. G.214 like G.41 is a good replacement for M.9 on replant sites.

Geneva® 969

Geneva® 969 is derived from a cross made in 1976 between Ottawa 3 and Robusta 5. G.969 was evaluated as CG.6969. Field trials indicate that G.969 is a semi-dwarfing rootstock between the size of M.26 and M.7 (Figs. 1-3). It is similar in size to two other Geneva rootstocks, G.935 and G.222. G.969 has very high productivity similar to G.935 but is resistant to woolly apple aphid while G.935 is not. G.969 as well as G.935 and G.222 appear to induce less biennial bearing with 'Honeycrisp' than other stocks (Fig. 4). It is resistant to fire blight (Russo et al., 2007) and *Phytophthora* root rot and has good anchorage in the orchard. It is easy to propagate in stoolbeds. Its tolerance to apple replant disease is not yet known. G.969 may be an excellent rootstock for use with weak scion cultivars like 'Honeycrisp' and 'Spur Red Delicious' in high-density plantings

Geneva® 210

Geneva® 210 is derived from a cross made in 1975 between Ottawa 3 and Robusta 5. G.210 was evaluated a CG.6210. There have been more than 20 field trials conducted with G.210, which have shown that it is a highly productive semi-dwarfing rootstock similar in vigor to M.7 (Robinson et al., 2003). Often its yield efficiency is similar to M.9. It is resistant to fire blight (Russo et al., 2007), *Phytophthora* root rot, and woolly apple aphid. It also has very good resistance to apple replant disease in field trials in New York (Isutsa and Merwin, 2001) and Washington (Auvil et al., 2011). It is not free standing and requires a trellis for supporting the trees, which can lean under wet soil conditions. Its high tolerance of apple replant disease suggests that it is a good replacement rootstock when weak scions are planted in replant soils or for organic production.

Geneva® 890

Geneva® 890 is derived from a cross made in 1976 between Ottawa 3 and Robusta 5. G.890 was evaluated as CG.5890. Field trials in New York State indicate that G.890 is a semi-vigorous rootstock either slightly larger than M.7 (Figs. 1 and 2) or slightly smaller than M.7 (Fig. 3). It is much more productive than M.7 and is resistant to fire blight (Russo et al., 2007), *Phytophthora* root rot, and woolly apple aphid. It is easy to propagate in stoolbeds and is free standing in the orchard. This rootstock is useful for medium density plantings for the processing market.

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Figures

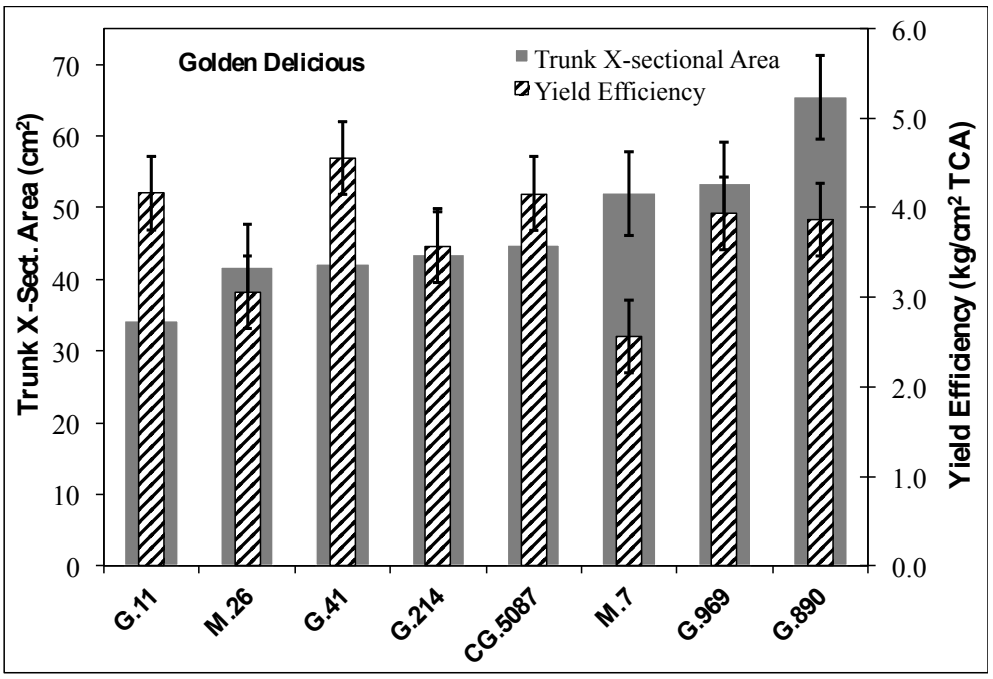

Fig. 1. Tree size and yield efficiency of 'Golden Delicious' apple trees on several Geneva® rootstocks over 10 years at Wolcott, NY.

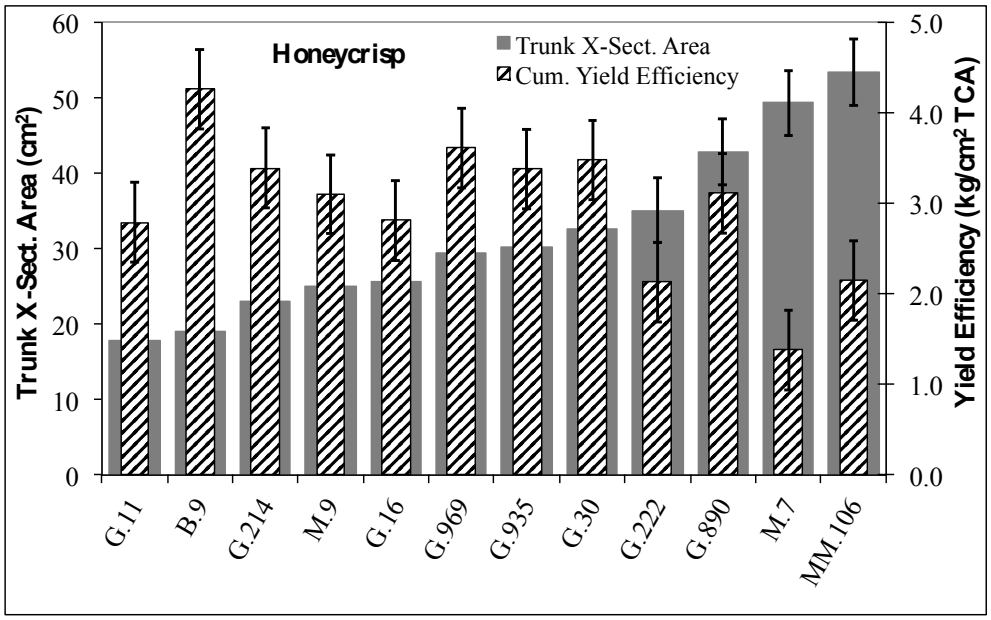

Fig. 2. Tree size and yield efficiency of 'Honeycrisp' apple trees on several Geneva® rootstocks over 7 years at Hilton, NY.

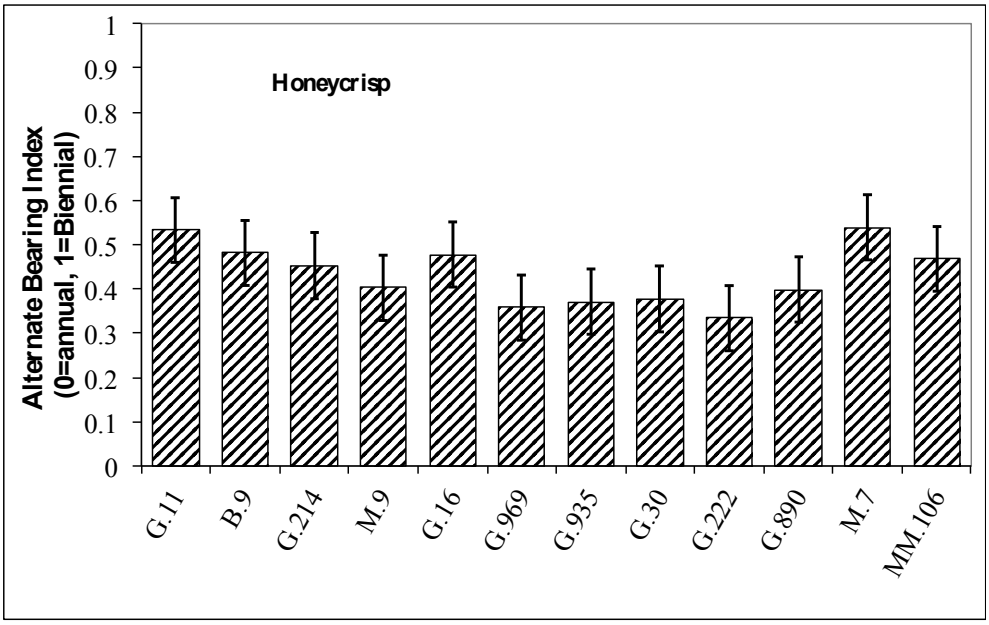

Fig. 3. Biennial bearing of 'Honeycrisp' apple trees on several Geneva® rootstocks over 7 years at Hilton, NY.

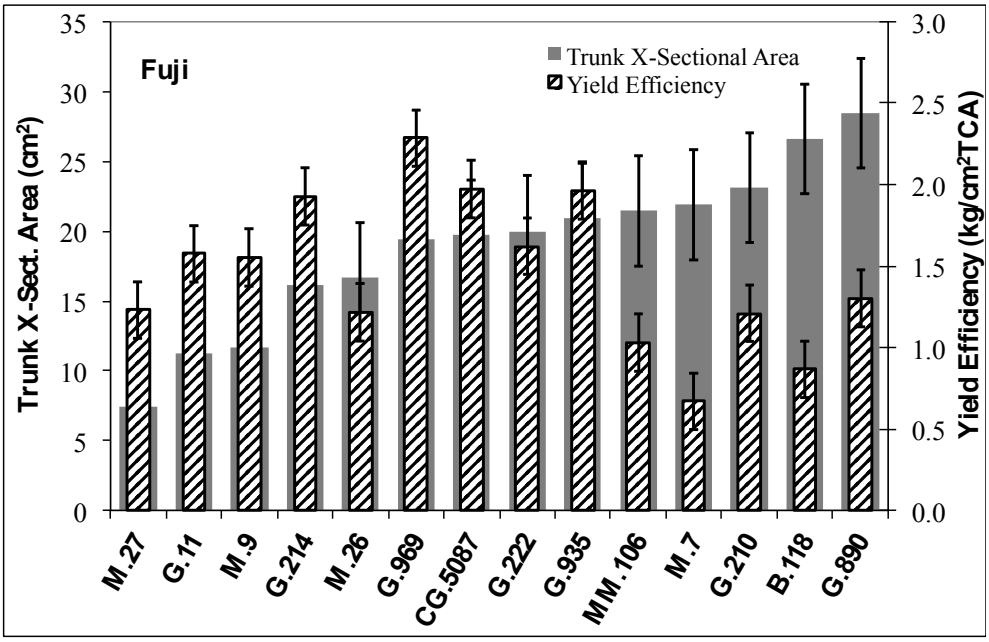

Fig. 4. Tree size and yield efficiency of 'Fuji' apple trees on several Geneva® rootstocks over 4 years at Marlboro, NY.