THE GENEVA® USDA/CORNELL APPLE ROOTSTOCK BREEDING PROGRAM

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A Bit of History:

The Geneva® Apple Rootstock Breeding program was initiated in 1968 by Dr. James Cummins and Dr. Herb Aldwinckle, with the objective of developing rootstock genotypes with improved nursery and orchard characteristics that are better adapted to the biotic stresses which are common in eastern North America of fire blight (*Erwinia amylovora*), and crown rot (*Phytophthora spp*). Dr. Cummins led the program until his retirement in 1993. In 1998 the Cornell University rootstock breeding program was converted to a joint breeding program with the United States Department of Agriculture (USDA) with a USDA breeder as the lead scientist (William Johnson from 1998-2000 and currently Gennaro Fazio) and with several Cornell scientists as cooperators. From the 30 year effort in apple rootstock breeding a large number of selections have been developed and are in various stages of testing of propagation characteristics in the nursery, and productivity and dwarfing in the orchard. The most advanced selections have been tested in orchard trials at the New York State Agricultural Experiment Station in Geneva, New York, on growers' farms across New York State, in multi-location national rootstock trials conducted by the NC-140, and in several other countries. Several nurseries around the world have been licensed to propagate the CG stocks but at the present time only nurseries in the USA and New Zealand have commercial production.

Current research:

Apple Replant Disease Tolerance Evaluation

We have seen evidence that some elite Geneva® Apple Rootstocks have resistance/tolerance to pathogens associated with the Apple Replant Disease (ARD) complex. We are conducting trials in cooperation with the Washington State Tree Fruit Research Commission and USDA ARS scientist Dr. Mazzola to elucidate genetic resisitance to ARD. We are also studying ARD in NY in collaboration Cornell scientists Dr. Merwin, Dr. Thies, and Dr. Nelson. As more land is replanted we hope to come up with the identification of environmentally friendly alternatives to soil fumigation in the form of apple rootstocks resistant to replant disease.

Apple Rootstock Fire Blight Resistance Evaluation:

In collaboration with Dr. Aldwinckle and Dr. Robinson we are confirming the field resistance to fire blight of Geneva® elite apple rootstocks. This is done by inoculating young trees (3-4th leaf) of the same scion and different rootstocks with strains of *E. amylovora*. The evaluation of the survivability of an apple rootstock to a field infection is quite a laborious and expensive task that is needed prior to release of these rootstocks in order to provide accurate planting recommendations to growers. Alternatives to the extremely susceptible M.9 and M.26 are needed in order to avoid tree loss caused by the rootstock phase of fire blight. The utilization of a resistant apple rootstock improves the survivability of a fire blight stricken tree – if the rootstock survives the grower is able to prune away scion branches and start over the next year a scenario that is much better than the loss of the whole tree.

Evaluation of Field Performance of Apple Rootstocks in Several US and Interanational Locations:

We are collaborating with several researchers and growers all over the US and the world to find rootstocks adapted to certain apple growing areas. International field trials in New Zealand, South Africa, Spain, Switzerland, Italy, Germany, Poland, France, are coordinated by Dr. Robinson and Dr. Fazio. We continue to search for the best growers to place field trials of 200-300 trees to gain and disseminate knowledge about the Geneva® series of rootstocks.

Disease Screening of Seedlings Derived from Recently Collected Wild Apple Accessions:

We are evaluating and utilizing disease resistance to fire blight, root rot, apple scab and other diseases that has been characterized by Dr. Aldwinckle (Cornell University) and Phil Forsline (USDA ARS PGRU Geneva) in wild apple accessions recently acquired by the USDA from Kazakhstan and other Asian countries. Breeding with new sources of resistance is important for the future development of apple rootstocks.

Evaluation of Scion Traits Modified by Apple Rootstocks:
We are researching how apple rootstocks change the shape (dwarfing, branch angle, etc.), and the productivity (flowering, precocity) of the scion. This research will enable us to develop molecular markers to select apple rootstocks that are dwarfing, yield efficient, amenable to mechanization and high density training systems.

Genetic Mapping and Marker Assisted Selection
We are developing the methods to utilize Marker Assisted Selection in the breeding program. Application of this methodology will cut years of time from the current development time of 30 years.

Trait Modification of Scion by Transgenic Rootstocks
One way to avoid the negative perception about GMOs in fruit trees is to utilize a transgenic rootstock to enhance the properties of the scion. The edible part of the tree will be non-GMO while still reaping the horticultural benefits of a transgenic scions.

Commercialized Geneva® apple rootstocks:

• **G.16** (a 1981 cross of 'Ottawa 3' X *Malus floribunda*) G.16 is a fully dwarfing rootstock with tree growth and vigor similar to vigorous clones of M.9 (i.e. Nic28 or Pajam2. Precocity and cumulative yield efficiency have been similar or slightly better than M.9. It is essentially immune to fire blight with no tree death from this disease in field trials. It has excellent performance in the stoolbed and produces a large tree in the nursery. Tree growth in the first 2 years in the orchard is vigorous but with the onset of cropping tree vigor is moderated similar to M.9. G.16 appears to have wide soil adaptability and some tolerance to replant disease. Its greatest deficiency it that it is sensitive to one or more latent viruses in scion wood. Infected scion wood results in death of the trees in the nursery or the first year in the orchard. This requires absolute use of virus free scion wood. A second problem is that a few trees of Gala and Joburn have snapped off at the graft union during high winds. The graft union strength has not been measured but it likely is no different than M.9 in the regard. Despite the limitations of G.16, it is currently one of the best alternatives to M.9 in high risk fire blight areas. It should be planted at high densities of 2000-6,000 trees/ha.

• **G.202** (a 1975 cross of 'Malling 27' X 'Robusta 5'). G.202 produces a tree similar in size to M.26. In addition to fire blight resistance, like other CG stocks, it also has good resistance to woolly apple aphid which is an important rootstock pest in many countries. It performs very well in the stoolbed and produces good quality nursery trees. G.202 has been tested mostly in New York state and New Zealand. In NY it is a similar in productivity to M.26 but not as productive as CG.935. In New Zealand it has been found to be much more productive than M.26 and is one of the best stocks available. It appears that G.202 will be a useful alternative to M.9 and M.26 in regions that have problems with Woolly Apple Aphid. Presently it is only available in New Zealand.

• **G.41** (a 1975 cross of 'Malling 27' X 'Robusta 5'). G.41 is a fully dwarfing stock with vigor similar to M.9. It is highly resistant to fire blight and *Phytophthora* with no tree death from this disease in field trials. Its precocity and productivity have been exceptional surpassing M.9. It also has excellent fruit size and induces wide crotch angles. It appears to be very winter hardy and showed no damage following the test winter of 1994. It produces a smaller tree than G.16 in the nursery and similar to M.9 which is very acceptable. It also does not have the virus sensitivity of G.16. Its only known flaws are it produces some side shoots in the stoolbed but not as many as G.30 and a few non trellised trees in one study in NY (10%) broke at the graft union following a high wind event. At the moment it appears that G.41 will be a possible replacement for M.9.

• **G.935** (a 1976 cross of Ottawa 3 X 'Robusta 5'). G.935 is a semidwarfing stock that produces a tree slightly larger than M.26. CG.5935 is the most precocious and productive semidwarf CG rootstock. It has had similar efficiency to M.9 along with excellent fruit size and wide crotch angles. It showed no symptoms of winter damage during the 1994 test winter. It is highly resistant to fire blight and *Phytophthora* but its resistance to woolly apple aphid is unknown. It has good propagability in the stoolbed and produces a large tree in the nursery. It appears that G.935 will be a possible replacement for M.26 when released.