Multistate Research Activity Accomplishments Report

Project Number: NC-140

Project Title: Rootstock and Interstem Effects on Pome-and Stone-Fruit Trees

Period Covered: Oct. 1, 2006-Sep. 30, 2007

Date of This Report: January 15, 2008

Annual Meeting Dates: November 12-13, 2007

Participants: See annual meeting minutes, available on the NC-140 web-site: http://www.nc140.org. The projects Email distribution list is maintained by W. Cowgill, (NJ) and J. Clements, (MA). The posting e-mail address is <nc140@virtualorchard.net>

Summary of Minutes: See annual meeting minutes, available on the NC-140 web-site: http://www. nc140.org/

Accomplishments and Impacts:

Objective 1: To evaluate the field performance of pome- and stone-fruit rootstocks in various environments and under different management systems, and to optimize experimental design for such evaluations.

The performance of pome and stone-fruit rootstock material is being evaluated in replicated, uniform trials in different climatic and edaphic environments through uniform multi-location field trials. From uniform trials planted across sites in North America that differ greatly in terms of environmental conditions and biotic and abiotic stresses, unbiased data is gathered to quickly assess new rootstocks in a timely fashion. These rootstocks are compared with industry standards, and from these comparisons, recommendations to growers can be made that are independent and backed by solid data. In developing such recommendations, consideration is given to not only productivity, but also to survival, cold tolerance, disease resistance, graft union integrity, and ease of management.

Several of our multi-state coordinated trials were concluded in 2006 or 2007 and data from these plantings have either been published or are being prepared for publication. These include:

- 1990 study of 14 plum rootstocks. The final report was published in the Journal of Amer. Soc. of Pom. in 2007.
- 1998 study of 3 apple rootstocks with Gala or Jonagold as the scions. The final report is in preparation and will be submitted for publication in the Journal of Amer. Soc. of Pom. in early 2008.
- 1998 Sweet Cherry study of 13 rootstocks. The final report is in preparation and will be submitted for publication in the Journal of Amer. Soc. of Pom. in 2008.
- 1998 Tart Cherry study of 12 rootstocks. The final report is in preparation and will be submitted for publication in the Journal of Amer. Soc. of Pom. in 2008.
- 2001 Peach study of 14 Prunus rootstocks. The final report is in preparation and will be

submitted for publication in the Journal of Amer. Soc. of Pom. in early 2008.
- 2002 Peach study of eight peach rootstocks. The final report is in preparation and will be submitted for publication in the Journal of Amer. Soc. of Pom. in early 2008.
- 2002 Peach physiology study. This trial compares the effect of location in North America on harvest date, fruit weight, and soluble solids content of Cresthaven Peach. The final report is in preparation and will be submitted for publication in HortScience in 2008.

In addition there are currently 10 on-going multi-state coordinated plantings from which data continue to be collected. These comprise 6 apple, 1 cherry, and 3 pear plantings. (see http://www.nc140.org/plantings.html for more details on planting design, rootstocks and locations). They are:

- 1999 Dwarf and Semi-dwarf Fuji/McIntosh apple rootstock trial which compares 21 apple rootstocks at 17 locations in North America. The trial has completed 9 years. A 5-year report was published in the Journal of Amer. Soc. of Pom. in 2006.
- 2002 Gala Apple rootstock trial which compares 20 apple rootstocks at 10 locations in North America. A 5-year report was prepared and submitted to the Journal of Amer. Soc. of Pom. for publication in 2008.
- 2002 Pear rootstock trial which compares 7 rootstocks at 4 locations in the USA. A 5-year report will be prepared for publication in 2008.
- 2002 Cameo apple trial which compares 3 rootstocks at 2 locations in the eastern USA. A 5-year report will be published in 2008.
- 2003 Golden Delicious apple rootstock trial which compares 23 rootstocks at 14 locations. A five year report will be prepared for publication in 2008.
- 2003 Golden Delicious physiology trial which compares the yield and fruit size performance of 3 rootstocks at 15 locations.
- 2004 Pear rootstock trial which compares 3 rootstocks at 3 locations in North America.
- 2005 Pear rootstock trial which compares 10 rootstocks at 5 locations in North America.
- 2006 Apple Replant Study which compares 12 rootstocks at 10 locations in fumigated and unfumigated soil at each site.
- 2006 Cherry Physiology Study which compares the yield and fruit size of a dwarfing cherry rootstock at 4 locations in North America.

The results of these trials have identified weaknesses and strengths of several new rootstocks. This information has guided the fruit industry and has saved the industry from investing millions of dollars in inferior rootstocks. Several rootstocks have been identified which are superior to existing rootstocks. This information is being used by nurseryment and fruit growers to help them improve the profitability and competitiveness of the USA fruit industry.

Objective 2: To assess and improve asexual propagation techniques of pome and stone fruit rootstocks.

New York State, in cooperation with the USDA, continues to work on techniques for the improved propagation of apple rootstocks. Experiments are underway with the shading, growth regulators (IBA, Cultar, NAA, Apogee) and tissue culture to improve rooting of hard to root new Cornell-Geneva rootstocks. This effort is necessary since the adoption of new rootstocks is limited by difficulties in propagation.

Objective 3: To develop improved pome- and stone-fruit rootstocks through breeding and genetic engineering, and to acquire new rootstocks from worldwide sources.

New York State, in cooperation with the USDA continues to breed new apple rootstocks which are disease resistant, cold hardy and productive. Forty three new rootstocks are under trial in NY state in 3 field trials. From these trials elite rootstocks will be selected and trialed in uniform NC-140 trials. Efforts by the USDA in Geneva, NY are continuing to confirm the identity of Cornell-Geneva series rootstocks around the world through molecular methods.

An ongoing breeding program in Arkansas is testing twelve new apple and 44 new peach rootstock selections. A breeding program in Michigan has developed a new series of tart cherry rootstocks which will be evaluated in the next NC-140 cherry rootstock trial. Breeding programs in California and Georgia are developing new peach rootstocks.

Objective 4: To understand the developmental and abiotic stress physiology of rootstock/scion interactions in pome- and stone-fruit trees.

Root cold hardiness G.5935 andM.26 was evaluated in a controlled freezing test in ME. This information will help predict rootstock performance during test winters which can cause large losses of trees on cold tender rootstocks.

Fire blight resistance of rootstocks from Geneva, NY, Vineland, Canada, Germany, Russia and England were evaluated in both NY and Ontario Canada. This information is essential to provide resistance to tree death from the periodic epidemics of fire blight which frequently occur in eastern North America and occasionally in Western North America.

Revision of Project Statement:

In 2007 the NC-140 Project technical committee submitted a revised project statement for 2008-2012 which was approved by the North Central Region Experiment Station Directors. The new name of the project is "Economic and Environmental Sustainability and Fruit Tree Production Through Changes in Rootstock Use." The objectives were revised as follows:

1. To evaluate the influence of rootstocks on temperate-zone fruit trees characteristics grown under different management systems and environmental conditions.
2. To develop and improve rootstocks for temperate-zone fruit trees with breeding and genetic engineering, to improve propagation techniques for rootstocks, and to acquire new rootstocks from worldwide sources.
3. To study the genetics and developmental physiology of rootstock/scion interactions in temperate-zone fruit trees.
4. To better understand the response to and impacts of biotic and abiotic stresses on scion/rootstock combinations in temperate-zone fruit trees.

Work Planned for Next Year.

Existing plantings will be maintained and data collection will continue according to protocols developed by the respective technical committees. Data coordinators will analyze and summarize data from the various sites for each coordinated planting, and will lead in writing 5 year progress reports and 10 year final reports for publication. Technical sub-committees for 4 fruit

commodities (apple, cherry, peach, and pear) have developed plans for future multi-state coordinated plantings which will support the new project objectives.

Apple Committee (T. Robinson, Chair.) Plans were finalized to proceed with the propagation of an apple rootstock trial to be planted in 2009 (25 rootstocks, primarily new Russian and Cornell-Geneva stocks) with Honeycrisp and Cameo as the scions. The trial will be planted at 20 locations in North America. T. Robinson (NY) will organize the trial and W. Autio (MA) will coordinate the data.

Cherry Committee (G. Lang, Chair.) Plans were developed to plant a tart cherry rootstock trial in 2010 (German, California and Michigan rootstocks). The trial will be planted at 3-4 locations in North America. G. Lang (MI) will organize the trial and coordinate the data. Plans were also developed to plant a sweet cherry rootstock trial in 2010 (PiKu stocks, Gi.12 and the best stocks from the 1998 trial). A coordinator for this trial has not yet been identified.

Peach Committee (G. Reighard, Chair.) Plans were finalized for a 2009 planting with 18 new rootstocks (to include Russian, Italian, UC-Davis clones and, Zaiger clones) with Redhaven as the scion variety. The trial will be planted at 18 locations in North America. Greg Reighard (SC) will organize the trial and coordinate the data.

Pear Committee (S. Castagnoli, Chair.) Plans were initiated to plant a high density pear rootstock trial in 2011 with cold hardy clones of quince and to plant a second trial in 2012 with the new Horner rootstocks from Oregon. Rachael Elkins (CA) and S. Castagnoli (OR) will organize the trials and coordinate the data. Plans were also initiated to plant an Asian pear rootstock trial in 2012. C. Walsh (MD) will organize and coordinate this trial.

Plum and Apricot Committees did not meet.

Outreach/Extension Activities:

The NC-140 project is recognized internationally as a leading source of comprehensive, unbiased data on field performance of tree fruit rootstocks. Information generated in this project is extended to fruit growers and fruit tree nurserymen across North America and to the world via the projects website, scientific publications (see publication list), popular articles in grower magazines (see publication list) at grower meetings (see extension presentation list) and orchard tours of the plantings in each cooperating state (see field tour list).

Website – Our project website at http://www.NC140.org/ serves as an important information portal for information developed by this project. The web site is hosted and maintained by W. Cowgill, (NJ) and J. Clements, (MA). Articles, photographs and research reports along with annual meeting minutes and annual project reports are archived throughout the year.

Grower Meetings: Each year several members of the NC-140 project make presentations to fruit grower audiences on the results of this project. A sample of presentations given in 2007 are:

- Emily Hoover (MN) - Apple Roostocks – What is New? MN Apple Growers Association Meeting. January 2007. LaCrosse, WI. Attendance 120
- Mike Parker (NC) Southeastern Apple Growers Meeting 10 January, 2007. Rootstocks and orchard densities for the southeast.. Asheville, NC. grower audience. attendance 110.

- Mike Parker (NC). Georgia Peach Growers. Maximizing productivity with Guardian – to fumigate or not? Byron, GA. grower audience. attendance 65.
- Terence Robinson (NY) Progress of the Geneva Rootstocks. International Fruit Tree Association, Hobart Australia. Attendance 300
- Terence Robinson (NY) Potential of the Geneva Rootstocks. South African Plant Improvement Organization, Cape Town SA. Attendance 300.
- Chris Walsh (MD) NC-140 trial results and recommendations. Bay Area Fruit growers meeting. Attendance 50.

Field Days: In each cooperating state the coordinated field trails are used as venues to present information from this project to fruit growers in each state. Each year a large number of cooperating states host field days. A sample of the field days held in 2007 are:

- Iowa Fruit and Vegetable Growers Association Field Day, Lisbon, IA. "Apple rootstocks and training systems" (Attendance 50)
- Wisconsin 2007 apple field day at the Peninsular Ag Research Station where the NC-140 plantings are located. Attendance was 125 growers and all had the opportunity to view the plantings and to ask questions about what has been learned.
- North Jersey Twilight Fruit Meeting, April, 2007; Rutgers Snyder Farm, Pittstown, NJ, "Tour of NC140 Research Plots- 46 attendees, growers
- New York - Cornell Fruit Field Day July 25. Geneva Experiment Station. Tours of apple and cherry rootstock plots. attendance 300.
- New York - Hudson Valley Fruit Field Day Aug 3 New Paltz, NY. Tours of apple rootstock plots. attendance 100.
- Two presentations on developments in tree fruit rootstocks were given to commercial grower audiences in Utah.

PUBLICATIONS

Refereed Journal articles:

Autio W., L. Anderson, B. Barritt, J. Cline, R. Crassweller, C. Embree, D. Ferree, E. Garcia, G. Greene, E, Hoover, S, Johnson, K. Kosola, J. Masabni, M. Parker, R. Perry, G. Reighard, T. Robinson. 2007. Early performance of 'Fuji' and 'McIntosh' apple trees on several dwarf rootstocks in the 1999 NC-140 rootstock trial. Acta Hort. 732:119-126.

Autio W., L. Anderson, B. Barritt, J. Cline, R. Crassweller, C. Embree, D. Ferree, E. Garcia, G. Greene, E, Hoover, S, Johnson, K. Kosola, J. Masabni, M. Parker, R. Perry, G. Reighard, T. Robinson. 2007. Early performance of 'Fuji' and 'McIntosh' apple trees on several semidwarf rootstocks in the 1999 NC-140 rootstock trial. Acta Hort. 732:127-134.

Blenda, A.V., I. Verde, L.L. Georgi, G.L. Reighard, S.D. Forrest, M. Muñoz-Torres, W.V. Baird, and A.G. Abbott. 2007. Construction of a genetic linkage map and identification of molecular markers in peach rootstocks for response to peach tree short life syndrome. Tree Genetics and Genomes DOI 10.1007/s11295-006-0074-9, 10pp.

Liu, X., G.L. Reighard, G.A. Swire-Clark and W.V. Baird. 2007. Peach rootstock identification by DNA-fingerprinting with microsatellite (SSR) markers. J. Amer. Pomol. Soc. 61(4): 162-166.

Masabni, J.G., P. Hirst, G. Brown, D. Wolfe, R. Perry, R. Andersen, J. Freer, T. Robinson, A. Azarenko, E. Mielke, B. McCluskey, G. Tehrani and W. Lay. 2007. Performance of plum

rootstocks with 'Stanley', 'Valor', and 'Veeblue' as the scion in the 1990 NC-140 multi-location plum trial. J. of the Amer. Pom. Soc. 61:196-207.

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Reighard, G., R. Andersen, J. Anderson, W. Autio, T. Beckman, T. Baker, R. Belding, G. Brown, P. Byers, W. Cowgill, D. Deyton, E. Durner, A. Erb, D. Ferree, A Gaus, R. Godin, R. Hayden, P. Hirst, S. Kadir, M. Kaps, H. Larsen, T. Lindstrom, N. Miles, F. Morrison, S. Myers, D. Ouelette, C. Rom, W. Shane, B. Taylor, K. Taylor, C. Walsh, and M. Warmund. 2007. Growth and yield of 'Redhaven' peach on nineteen rootstocks at twenty North American locations. Acta Hort. 732:271-278.

Reighard, G.L., D. R. Ouellette, and K. H. Brock. 2007. Survival, growth and yield for Carogem peach on an interstem and two dwarfing rootstocks. Acta Hort. 732:303-306.

Robinson, T. 2007. Recent advances and future directions in orchard planting systems. Acta Hort. 732:367-382.

Robinson, T. 2007. Effect of tree density and tree shape on light interception, tree growth, yield and economic performance of apples. Acta Hort. 732:405-414.

Robinson, T.L., R.L. Andersen and S.A. Hoying. 2007. Performance of six high density cherry training systems in the northeastern United States. Acta Hort. 732:421-428.

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Russo, N., T.L. Robinson, H.S. Aldwinckle and G. Fazio. 2007. Horticultural performance and fire blight resistance of Cornell-Geneva apple rootstocks and other rootstocks from around the world. *HortScience* 42:1517-1525.

Tanner, Shann Cory. 2007. Peach Tree Root Demography and Soil Microbial Characteristics in Peach Replant Soils. M.S. Thesis. Clemson University 113 pp.

Zhebentyayeva, T., D.A. Lalli, D. Jiwan, J.H. Jun, J.. Duncan, D. Main, G. L. Reighard, R. Scorza and A. G. Abbott. 2007. From BAC to trait and back: Exploiting structural and functional genomics databases for gene identification in peach. Acta Hort. 738: 711-717.

Non-Refereed Journal Articles:

Crassweller, R., and D. Smith. 2007. Rootstock and cultivar evaluations - 2006. PA Fruit News 87(2):60-62.

Lang, G. 2007. Timing critical to develop precocious sweet cherries. Fruit Growers News 46(2)12-15.

Lang, G. 2007. High tunnel production systems work for dwarf sweet cherries. Fruit Growers News 46(4)34-36.

Lang, G., H. Demirsoy and L. Demirsoy. 2007. Bodur kirazlarda goz yonetimi. Hasad Bitkisel Uretim 22(263):56-59.

Lang, G., R.L. Andersen, T. Robinson, H.Demirsoy, and L. Demirsoy. 2007. Gisela anaclari uzerineki kirazlarin bakimi. Hasad Ditkisel Uretim 23(266):60-64.

Padilla-Zakour, O., Ryona, I., Cooley, H.J., Robinson, T.L., Osborne, J. and Freer, J. 2007. Shelf-life extension of select sweet cherries by field management, post-harvest treatments and modified atmosphere packaging. NY Fruit Quarterly 15(2)3-6.

Robinson. T.L., S.A. Hoying, A.M. DeMarree, K.I. Iungerman and M.J. Fargione. 2007. The evolution towards more competitive apple orchard systems in New York. NY Fruit Quarterly 15(1)3-7.

Robinson. T.L., G.L. Reginato and S.A. Hoying. 2007. Sistema Tall Spindle: Alternativa para la conduccion de huertos de manznos en alta densidad. Rev. Fruiticola 28(1)29-33.

Published Abstracts:

Carroll, J, Robinson, T. and Burr, T. 2007. Effect of early-spring-pruning and copper sprays for managing bacterial canker of sweet cherry. Phytopathology 97:S177

Carroll, J, Robinson, T. and Burr, T. 2007. Managing bacterial canker of sweet cherry: Contributions of copper sprays, pruning stubs, training system and cultivar. Proceedings of the 2007 Great Lakes Fruit Workers Meeting Abstracts p.7.

Liu, X., G.L. Reighard, G. Swire-Clark, and W. V. Baird. 2007. Identification of peach [*Prunus persica* (L.) Batsch] rootstock seedlings using DNA-fingerprinting with microsatellite (SSR) markers. Botany & Plant Biology Joint Congress 2007. Chicago, IL. July 7-11, 2007. Poster Abstract Book p. 277.

Liu, X., G.L. Reighard, G. Swire-Clark, and W. V. Baird. 2007. Peach rootstock seedling identification by DNA fingerprinting with microsatellite (SSR) markers. HortScience 42(4):1007.

Reighard, G.L. 2007. Avances en el manejo de huerto: variedades y patrones. Carozos II: Ciclo de Seminarios Frutocolas de Actualization Tecnico Comercial. Santiago, Chile. August 21-22, 2007. Abstract.

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Robinson, T.L., S. Hoying, R. Andersen, and G. Reginato. 2007. Performance of high-density peaches in New York state. HortScience 42: 914(Abstr.)

Robinson, T.L., S. Hoying, R. Andersen, and G. Reginato. 2007. Yield and fruit size of different peach training systems. Proceedings of the 2007 Great Lakes Fruit Workers Meeting Abstracts p.66.

Russo N. L., H.S. Aldwinckle, T. L. Robinson and G. Fazio. 2007. Budagovsky 9 rootstock: Uncovering a novel resistance to fire blight. Int. Fire Blight Symposium Programme and Abstracts p.)

Russo N. L., T. L. Robinson, G. Fazio and H.S. Aldwinckle. 2007. Evaluation of apple rootstocks for resistance to fire blight and orchard performance. Proceedings of the 2007 Great Lakes Fruit Workers Meeting Abstracts p.68.

Other Publications:

Agnello, A.M., A. Landers, D.A. Rosenberger, T.L. Robinson, J.E. Carroll, L. Cheng, P.D. Curtis, D.I. Breth, and S.A Hoying. 2007. Pest management guidelines for commercial tree-fruit production 2007. Cornell University, Ithaca NY 252 pp.

Carroll, J., Robinson, T. and Burr, T. 2007. Importance of early-spring-pruning copper sprays and training systems in managing bacterial canker of sweet cherry. 2006 New York State Fruit IPM Project Reports. NYS IPM Program Publication 222: 49-54/.

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Robinson. T.L., S.A. Hoying and A.M. DeMarree. 2007. A more competitive apple planting system: The Tall Spindle. Proc. of the 2006 Empire State Fruit and Veg. Expo. p. 1-4.

Ward D., Loki, G., W.P. Cowgill Jr., J.L. Frecon, G.C. Hamilton, J.R. Heckman, L.S. Katz, N. Lalancette, B.A. Majek, D. Polk, P.W. Shearer, W.H. Tietjen. 2007. "New Jersey Commercial Tree Fruit Production Guide." Rutgers Cooperative Extension Bulletin E002: pp. 101-108

Appendix: Individual State Accomplishments and Impacts 2007

California: In the 2003 Golden Delicious trial more than half the trees on M.26 and M.9 have died from fireblight. In addition, six trees on experimental rootstocks died in 2007. Two were on B.9, a rootstock too weak for California conditions. Of the other four trees, two broke off below the graft union. One was on CG.5935 and the other on CG.4210. A third tree, on PiAu 51-11, broke right at the graft union. All three were not staked very well and appeared healthy before they snapped under heavy crops or high winds. The final tree was on JM.2 and probably died from fireblight. Thus, the experimental rootstocks have generally survived fireblight quite well, especially the CG series stocks. In the Pear rootstock trials, survival rate was poorest for Fox 11, Pyro 2-33. The largest trees were on Horner 4 and OHF69 (Mendocino County only) however Horner 4 struggled in the heavy clay soil in Sacramento County.

Colorado: The 1998 sweet cherry rootstock trial is being used for a preliminary study on control options for Cytospora canker of stone fruit and plant parasitic nematodes associated with the rootstocks in Colorado soils

Iowa: In the 2003 Golden Delicious apple rootstock trial, off-type rootstocks have been identified for JM.1, JM.5, JM.7 (3) and JM.8. Based on trunk cross sectional area, trees on PiAu 51-4, JM.2, PiAu 36-2, PiAu 56-83 and JM.5 continue to be the largest, while trees on J-TE-G, and B.9 remain the smallest. Trees were exposed to -11.1 C (12 F) on 7April when the buds were at the green-tip stage of development. Most king and advanced lateral blossoms were killed leaving one to three blossoms per cluster. Trees on JM.7, J-TE-G, CG.5935, B.9 and G.16 have been the most productive, while trees on JM.5, and PiAu 56-83 remain the least productive. In the 2003 Apple Physiology study, increasing crop loads reduced tree growth as measured by changes in trunk cross-sectional area, and average fruit weight. Return bloom for trees on G.16 remained high regardless of crop load, while it dropped off as crop load increased for trees on M.26 and M.9 T337.

Indiana: During flowering, overnight minimum temperatures were below freezing for 7 consecutive nights, with temperatures dropping as low as 20 F. These temperatures caused widespread flower damage in the NC-140 plots which prevented meaningful data from being collected.

Kentucky. All of the NC-140 trials in Kentucky had severely reduced yields in 2007 as a consequence of a series of devastating freezes that affected all fruit crops in Kentucky. Among the dwarf rootstocks planted in 1999, CG.41 and CG.4013 yielded the most fruit, while G.30N yielded the most fruit among the semi-dwarf trees. In the 2002 rootstock trial, M.9 Burgmer756 yielded the most fruit over the past four seasons. Trunk cross-sectional area was highest for P.14 followed by M.9 Burgmer756. Cumulative yield efficiency was the highest for the two B.9 rootstocks. In the 2003 trial, trees on PiAu56-83 have the highest cumulative yield, and were the most vigorous. Trees in the physiology trial were thinned differentially to crop loads of 2, 5, 8, 11, and 14 fruit per square centimeter of trunk cross sectional area in 2006. Return bloom in 2007 was inversely correlated with crop density in 2006.

Maine: In the 2003 Golden Delicious rootstock trial seven rootstocks were smaller in trunk size than M.26 and eleven were larger. Geneva rootstocks had the heaviest crop load and smaller mean fruit size as a consequence. Fruit size of JM7 did not correspond with crop load, it was small even though crop load was near average for the season. 2. In the 2003 Physiology trial, trees on M.9T337 were smaller than G.16 and M.26. Increase in yield with increase in fruit density appeared to plateau above 8 fruit per cm2 TCA in a similar manner for all three rootstocks. Individual fruit weight did not appear to be affected by fruit densities below 8 fruit per cm2 TCA, but decreased at densities above 8 fruit per cm2 TCA. Our work on cold hardiness of new apple rootstocks found that G.16 was as cold hardy as M.26 EMLA. Significant root death (>10%) and poor shoot growth occurred in both rootstocks following exposure to temperatures below -10 °C.

Maryland: In the 2001 and 2002 peach rootstock trials, Controller 5 and Controller 9 rootstocks had a 25% reduction in tree size compared to the standard Lovell rootstock and both had 100% survival in this very difficult site. Local recommendations based on NC140 results have allowed Maryland fruit growers to increase production while reducing cost.

Massachusetts: In the 1999 apple rootstock trial the largest trees were on CG.4013 and G.202, and the smallest were on M.9 NAKBT337, Supporter 1, Supporter 2, and Supporter 3. Trees on G.16 were smaller, but not significantly smaller, than those on M.26 EMLA, and trees on CG5179 and on G.41 were larger than those on M.26 EMLA. Cumulatively (2001-07), the trees on Supporter 3 were significantly more yield efficient than those on G.16N or M.26 EMLA. Trees on Supporter 1 and Supporter 2 were also more yield efficient than those on G.16N. In the semi-dwarf trial the largest trees were on M.7 EMLA, Supporter 4, and G.30N, all significantly larger than those on M.26 EMLA, CG.4814, and CG.7707. Cumulatively (2004-07), CG.4814 resulted in the most yield efficient trees, followed by those on CG.7707, M.26 EMLA, G.30N, Supporter 4 and M.7 EMLA. In the 2002 apple rootstock trial, the largest trees were on PiAu51-4, followed in decreasing size by those on P.14, M.26 NAKB, PiAu51-11, Supporter 4, M.26 EMLA, M.9 Burgmer 756, M.9 NAKBT337, M.9 Nic 29, B.9 (Treco), and B.9 (Europe). Cumulatively (2004-07), the two B.9 strains resulted in the greatest yield efficiency, while PiAu51-4 resulted in the lowest. In the 2003 rootstock physiology trial with Golden Delicious, incremental growth in 2007 declined with increasing crop load and was greatest for trees on M.26 EMLA. Trees on M.9 NAKBT337 and on G.16 were similar. Fruit size was negatively related to crop load.M.9 NAKBT337 resulted in the largest fruit and G.16 and M.26 EMLA resulted smaller and similarly sized fruit. Rootstock interacted with crop load to affect flesh firmness. The impact of crop load on fruit from trees on M.9 NAKBT337 was variable but was more consistently negative with M.26 EMLA and G.16. M.9 NAKBT337 resulted in the highest soluble solids concentration (SSC), and M.26 EMLA resulted in the lowest. Crop load interacted significantly with rootstock to affect SSC. The negative effect was most consistent with fruit from trees on M.26 EMLA and on G.16. SSC of fruit from trees on M.9 NAKBT337 was negatively affected by increasing crop load, possibly to a lesser degree than the other rootstocks. Starch contents also were affected by rootstock, with fruit from trees on G.16 and on M.26 EMLA having the lowest contents and those from trees on M.9 NAKBT337 having the highest content. Crop load was negatively related to starch content. Ethylene concentrations were similar in the core cavity of fruit from trees on G.16 and M.9 NAKBT337. The concentration was lower in fruit from trees on M.26, suggesting that these fruit were the least ripe. Crop load and rootstock interacted significantly. Crop load consistently and negatively affected internal

ethylene for G.16 and M.26 EMLA. The relationship was more variable and less pronounced for M.9 NAKBT337. Increasing crop load delayed ripening by as much as 3 weeks from light set to heavy set. On average, fruit from trees on M.9 NAKBT337 ripened 1.2 days before those from trees on G.16, and fruit from trees on M.26 EMLA ripening 3.8 days later than those on G.16.

Michigan: G.30T has performed well with McIntosh over 9 years in the sandy infertile soil at the NWHRS, suggesting commercial promise for this region. CG.5890 has performed well with Golden Delicious over 6 years at the same site. G.41 (CG.3041) has performed very well with McIntosh over 9 years in the more fertile soil at Clarksville, as has Supporter 2 and 3. In the 1998 cherry rootstock trial with Montmorency tart cherry, Weiroot 72 (W.72) has been consistent over the past 4 years, suggesting that it may be very promising for higher density Montmorency orchards if mechanical harvesters suitable for high density orchard operation are developed. W.13 has also performed very well over the life of the trial, having the highest cumulative yield efficiency. The 2007 collapse and death of all trees on Gisela 7 and Gi 195/20 after 10 years illustrates the value to industry of the NC-140 project, in that such a collapse (presumably due to virus sensitivity and cold injury) of a commercial orchard, just as it reaches mature production could be economically devastating. The use of precocious, dwarfing rootstocks such as Gi.5 is essential for Great Lakes region fresh market sweet cherry production in high tunnel systems.

Minnesota: Yield was much reduced over past year because of a wind storm blew fruit off. The remaining fruit was particularly small because of the drought conditions. In the dwarf planting, Supporter 1 was the smallest tree and CG.4013 the largest. Yield for the Cornell-Geneva rootstocks was almost always significantly higher in the dwarf planting than the other rootstocks under evaluation. This research allows us to test the environmental adaptability of rootstock/scion combinations.

New Jersey: The New Jersey/UMASS G.16 Cameo NC140 Rootstock Trial has shown that B.9 had the highest cumulative yield efficiency. Cameo/B.9 is being planted in significant numbers in NJ. In the 2002 apple rootstock trial, PiAu51-4, PiAu51-11 and P.14 had the lowest yield efficiency and B.9 Europe has the highest yield efficiency. B.9Europe was severely impacted with burrknots with 68% of the shank covered while B.9Treco had 10.7%. Both M.26NAKB and M.26EMLA had no rootsuckers, while B.9 Europe had the most. B.9 Europe should not be planted in NJ. In the 2006 apple replant trial, TCSA, yield, and yield efficiency was significantly different with both fumigation treatment and rootstock. Fruit size (g) was significantly affected only by rootstock.

New York: In the 1999 apple rootstock trial G.41 had the best combination of survival, yield, yield efficiency and fruit size for rootstocks in the M.9 size category. G.935 was the best stock in the M.26 size class. Other superior stocks were G.16 Supporter 2 and Supporter 3. In the 2002 apple rootstock trial G.935 was the most efficient and was similar in tree size to M.9 and G.41 while B.9 was smaller but also highly efficient. In the 2003 apple rootstock trial G.41 had the best combination of survival, yield, yield efficiency and fruit size for rootstocks in the M.9 size category. B.9 was very efficient but was too dwarfed to be of practical value. G.935 was similar in size to G.41 and similar in yield efficiency. A new stock which performed well and was similar in size to M.26 was B.62-396 (B.10). A pruning study overlaid on the 1998 sweet cherry rootstock trial showed a trend toward larger fruit size from spur extinction pruning or stubbing

back pruning even of dwarfing stocks. Nevertheless the dwarfing stocks continued to produce smaller fruit size. Analysis of covariance showed that the difference in fruit size was largely the result of high crop loads with the dwarfing stocks. Two large summer field day was conducted at the Geneva Experiment Station and in the Hudson Valley where apple rootstock and cherry rootstock plots were showcased and discussed.

North Carolina: In the 1998 planting, trunk cross-sectional area (TCSA) of trees on G.16 was numerically greater than those on M.9 EMLA and M.9NAKBT337, although they were not significantly different. Through 2006, trees on G.16 had the greatest cumulative yield which was significantly greater than that of trees on M.9EMLA which had the least. In the 1999 dwarf Fuji planting, trees on CG.4013 had the largest TCSA and trees on M.9NAKBT337, Supporter1, 2, and 3 had the smallest. Trees on CG.5935 had the greatest cumulative yield and trees on Supporter 1 the lowest. In the 1999 semi-dwarf planting, trees on CG.6210 were the largest and those on CG.4814 the smallest. Cumulative yield was greatest for trees on CG.6210 and the lowest was for trees on M.7 EMLA. In the 2006 apple replant study, there was not a significant difference in the TCSA between the fumigated trees and those that were not fumigated. Trees on CG.935 were the largest in the dwarf category and those on M.7 were the largest in the semi-dwarf category. The data collected from this project continues to help growers in the Southeast in rootstock selection for high to medium density orchards.

Oregon: In the 2002 d'Anjou Pear rootstock trial, OHxF 87 ranked first for yield and yield efficiency. A screening trial is being conducted with the Horner rootstock series in Hood River. The Horner clones have been established in trials initiated in 2004 through 2006 with d'Anjou as the scion. These are single tree plots with two to three replicates per clone and will be evaluated for approximately five years. D'anjou, Bartlett, and Bosc trees are being propagated on Horner 4, Horner 10, and OHxF 87 for planting in systems trials scheduled to be planted in spring 2009 at several locations in Washington and Oregon. The 2002 PiKu 1 and 3 Sweet Cherry Rootstock Trial has been removed as a result of disease incidence and unacceptable growth and performance of the trees. In the 2002 Sweetheart/MxM Trial, MxM60 and MxM2 trees have the greatest vigor. Trees exhibit only few symptoms of bacterial canker. In the 2003 Skeena/Krymsk Rootstock Trial, Krymsk 6 trees had the largest TCSA and a loss of one tree. Krymsk 5 trees have a similar TCSA as Gisela 6, 60% mortality, and suckers. Mazzard trees have similar TCSA to both Gisela 6 and Krymsk 5 trees. In the 2005 Regina Rootstock Trial, although there were no significant differences in vigor, Gisela 5 and 12 had the greatest increase in TCSA followed by Mazzard and Gisela 6. Mortality, due to cool spring temperatures during bloom and increased Pseudomonas pressure, occurred in three Mazzard and one Gisela 6 tree. In the 2003 Training Systems and Rootstock Trial, all three cultivars trained to a multiple leader had greater vigor and yield than central leader trees. Central leader trees have a larger TCSA on MxM14, while multiple leader trees are larger on Gisela 6. Central leader Stardust trees yielded more on MxM14 while Gisela 6 trees produced the highest yields on multiple leader trees. Stem pullforce did not differ significantly at harvest but after two weeks in storage, fruit from Gisela 6 trees had higher stem pullforce measurements for both CL and ML trees. There was mass mortality among Gisela 6 and Giessen 196-4 trees, especially in Stardust which led to the removal of this cultivar from the trial. The modified Tatura trellis does not fare well in Willamette Valley conditions due to the incidence of bacterial canker that occurs where trellis wires rub the trunk. A frost at bloom severely affected the flowers of Sweetheart resulting in no crop. A Pseudomonas resistance trial

has been established in Hood River with Sweetheart, Sylvia, Bing, Regina on Mazzard, Gisela 6, Giessen 196-4.

Pennsylvania: Jonagold / G.41 trees in the 1998 apple rootstock trial had high mortality and symptoms consistent with graft union necrosis. In 2007 we sampled tissue from all three rootstocks, M.9, G.16, and G.41 for tomato ringspot virus (TRSV) by reverse transcripton polymerase chain reaction (RT-PCR). The samples tested positive for TRSV, which further suggests that G.41 may be susceptible to this important Mid-Atlantic pathogen. Fuji trees on all three Supporter rootstocks are declining with similar symptoms in the 1999 apple rootstock trial in Biglerville. Fuji trees on Supporter rootstocks are also declining in the 1999 planting at Rock Springs, while McIntosh trees on these same rootstocks appear normal. After the final horticultural data set is complete we plan to evaluate tissue from trees from the Biglerville site for TRSV. A planting of a wide range of CG rootstocks was planned in cooperation with Dr. Gennaro Fazio to screen advanced selections for field susceptibility to TRSV.

South Carolina: In the 1999 Fuji apple rootstock trial one tree of Supporter 2 and one of Supporter 3 died due to *Phytophthora spp*. Trees on Geneva 16N rootstocks continued to be the most vigorous, whereas trees on Supporter 3 rootstocks were the least vigorous. Fruit size was similar across rootstocks, with no significant differences. Fruit yield was highest with Supporter 2 rootstocks and fruit yield was lowest with Supporter 1 and Supporter 3 rootstocks. Trees on Supporter 2 had the highest yield efficiency over the last 7 years. Root sucker counts were highest with Geneva 16N rootstocks. For the semi-dwarf planting, M.26 rootstocks were the most vigorous and produced the largest fruit. Cumulative yield efficiency continues to be much higher with CG.814 and Supporter 4 than with M.26. Suckering was most prevalent with CG.814.

Utah: The 2007 season had one of the most widespread and destructive outbreaks of fire blight on record. As a result of the degree of infection, the 1999 apple block was removed, and significant damage was also observed in the two 2003 apple blocks. Two presentations on developments in tree fruit rootstocks were given to commercial grower audiences in Utah. Based on these results, growers will be avoiding several of the new clonal peach rootstocks that were shown to lack the vigor and hardiness required for Utah's climate and growing conditions.

Wisconsin: In the 1999 apple rootstock trial, CG.41 had the highest yield efficiency yet was among the largest trees. CG.13 had the largest increase in TCSA. In the 1999 semi-dwarf trial CG.30 is still intermediate in size yet has the highest yield efficiency with good fruit size. Yield efficiency of CG.707 and EMLA 26 were lower than the other rootstocks. In the 2003 apple rootstock trial, CG.5935 was the most yield efficient while PiAu 56-83 was the least yield efficient. We did not meet the goal of obtaining 3 fruit per cm^2 TCSA. Actual crop load varied between 3 and 12 fruit per cm2 TCSA. In the 1998 tart cherry trial, W10 and G6 continue to have the highest yield. W53 had the lowest yield by far. These trees appear to have runted and many trees have been lost. The data from these plantings is used to advise apple and cherry growers about which rootstocks should do well in their locations.