Multistate Research Activity Accomplishments Report
Project Number: NC-140
Project Title: Economic and Environmental Sustainability and Fruit Tree Production Through Changes in Rootstock Use
Period Covered: Oct. 1, 2008-Sep. 30, 2009
Date of This Report: December 21, 2009.
Annual Meeting Dates: November 2-3, 2009

Participants: See annual meeting minutes, available on the NC-140 web-site: http://www.nc140.org. The project's 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 influence of rootstocks on temperate-zone fruit trees characteristics grown under different management systems and environmental conditions.
Status of concluded projects:

- 1999 Dwarf and Semi-dwarf Fuji/McIntosh apple rootstock trial which compares 21 apple rootstocks at 17 locations in North America. Final reports are in preparation and will be submitted to the J. Amer. Pom. Soc.
- 2001 Peach trial of 14 *Prunus* rootstocks. The final report is near completion, and will be submitted for publication in the J. Amer. Pom. Soc. The report will include a data table summarizing each site, making it more readily accessible to fruit growers.
- 2002 Peach trial of three peach varieties on eight roostocks. A report was published in Fruit Notes.
- 2002 Cresthaven peach physiology trial, comparing the effect of location in North America on harvest date, fruit weight, and soluble solids content. The final report is in preparation and will be submitted for publication in the J. Amer. Pom. Soc. in 2009.

Ongoing projects:

- 2002 Gala apple rootstock trial compares 20 apple rootstocks at 10 locations in North America. A five year summary was prepared and published in the Journal of the American Pomological Society.
- 2002 Cameo apple rootstock trial compares 3 rootstocks at 2 locations in the eastern USA.
- 2002 Pear rootstock trial compares 7 rootstocks at 4 locations in the North America.
- 2003 Golden Delicious apple rootstock and physiology trials compares 23 rootstocks at 14 locations. A five-year summary was published in the Journal of the American Pomological Society during 2009.
- 2004 Pear rootstock trial compares 3 rootstocks at 3 locations in North America.
- 2005 Pear rootstock trial compares 3 to 8 rootstocks with Bartlett and 7 rootstocks with Bosc at 6 locations in North America.
- 2006 Gala apple replant trial compares 12 rootstocks at 10 locations in fumigated and unfumigated soil at each site.

- 2006 Cherry physiology trial compares the yield and fruit size of a dwarfing cherry rootstock at 4 locations in North America.
- 2009 Peach rootstock trial compares 18 rootstocks at 14 locations in 12 states was planted. A companion study on crop load physiology was also planted in 2009.

Objective 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.

- Development of new rootstocks: New York State, in cooperation with the USDA continues to develop and test new rootstocks. Two tests with Honeycrisp and Fuji are helping to identify new elite clones.
- Propagation of apple rootstocks: New York State, in cooperation with the USDA continues to work on techniques to improve propagation of apple rootstocks – primarily difficult-to-root Geneva rootstocks such as G41. These include planting density, plant orientation, tissue culture, early-season shading, and growth regulators.

Objective 3. To study the genetics and developmental physiology of rootstock/scion interactions in temperate-zone fruit trees.

- In NY, a joint trial is being done on the mapping of root architecture traits on the genome. A population of unscreened seedling is being evaluated for root morphological characters which will allow mapping of root architecture characteristics.
- 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 better understand the response to and impacts of biotic and abiotic stresses on scion/rootstock combinations in temperate-zone fruit trees.

- Apple rootstock tolerance to soil pH is being evaluated in NY. A field trial in pots of Golden Delicious on 30 Geneva rootstocks is being conducted for tolerance to low and high soil pH. This trial began in spring, 2008. Tree growth and root growth will be evaluated in 2010.
- Apple rootstock tolerance to replant disease is being evaluated in NY. A field trial in pots of Golden Delicious on 30 Geneva rootstocks is being conducted for tolerance to replant disease in both sandy and clay soils. This trial began in spring, 2008. Tree growth and root growth will be evaluated in 2009.
- Cold Hardiness Testing of New Apple Rootstocks continues in ME. G.5935 had greater root tissue cold hardiness than M.26 EMLA, based on shoot growth following exposure to freezing temperatures to a low of -16 °C.

Work Planned for Next Year

Existing plantings will be maintained and data collection will continue according to protocols developed by the respective technical committees. Planting 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 project objectives.

Apple Sub-Committee (T. Robinson, Chair) Plans were finalized to proceed with a multi-state apple rootstock trial to be planted in 2010. The trial will consist of 31 rootstocks, including new Russian and Geneva rootstocks, with Honeycrisp and Fuji as the scions. The trial will be planted at 21 locations in North America. T. Robinson (NY) will organize the trial and W. Autio (MA) will coordinate the data.

Cherry Sub-Committee (G. Lang, Chair) Plans were developed for a high-density sweet cherry trial to be planted in 2010. This trial will evaluate three dwarfing rootstocks and three training systems. The trial will be planted in WA, MI, OR, NY, and NS, with cultivars differing by state. Two independent 2010 plantings of high-density tart cherries will be planted in UT and MI for mechanical harvest. The UT trial will evaluate three rootstocks at multiple row spacings with Montmorency as the scion. The MI trial will evaluate four rootstocks and own rooted Montmorency with three training systems. G. Lang (MI) will organize the trials and coordinate the data.

Peach Sub-Committee (G. Reighard, Chair) Protocols were discussed for managing the 2009 peach rootstock and physiology trials. Reighard (SC) will organize the trial and coordinate the data.

Pear Sub-Committee (T. Einhorn, Chair) Plans were developed for a 2012 pear rootstock x training x spacing planting at four locations: NY, OR, (possibly a WA site) and CA. Scion selection will vary, based upon regional interests, and will be budded on OHxF 87, OHxF 69, and Pyro 2-33. Spacing and training systems will facilitate moderate to high-density designs. T. Einhorn (OR) will organize the trial, and coordinate the data.

Extension/Outreach Activities

Website: The NC-140 web site, www.nc140.org continues to be our out reach component. The NC-140 web site also serves as an important collaboration tool for cooperators who can communicate via an e-mail list, and upload/download Project files to password-protected directories. The Internet registration for http://www.NC14.org/ continues to be maintained. The web site is hosted and maintained by Win Cowgill, NJ and Jon Clements, UMASS. An online Filemaker database that is self-editing contains the cooperator contact information. Requirements for web page design for regional projects have been met as outlined by the Cooperative State Research, Education, and Extension Service (CSREES) and the North Central Regional Association of Agricultural Experiment Station Directors (NCRA). Articles, photographs and reports were archived throughout the year.. The website had 44,600 visits November 2008 to October 2009. The monthly statistics were as follows: 3,725 average monthly visits, 220 average monthly MB's, 4,397 average monthly pages, 6,500 average monthly hits. The percent of the visits: 62 North America, 18 Unknown, 10 Europe, 9 Asia, 1 Middle East, <1 Australia, South America, Africa.

Grower Meetings and Field Days: Each year several members of the NC-140 project make presentations to fruit grower audiences on the results of this project. Similarly, in each cooperating state the coordinated field trials are used as venues to present information from this project to fruit growers at field days. A sample of the presentations given and field days held in 2009 is provided below:

"NC-140 2003 apple rootstock trial" All-Horticulture Field Day, Iowa State University Horticulture Research Station, Ames, IA. Domoto, P. 6 Aug 2009 (Attendance 300).

"Summary of Apple Research". Maine Ag. Trades Show. Augusta, ME, Moran, R. 14 Jan 2009. (Attendance 60)

"Apple Tree Architecture: Rootstock and Training Trials." Western Maryland Regional Fruit Meeting. Keedysville, MD. Walsh, C.S. 19 Feb 2009. (Attendance 50).

"Apple Tree Architecture: Rootstock and Training Trials." Bay Area Fruit School. Queenstown, MD. Walsh, C.S. 27 Feb 2009. (attendance 42).

"Apple Tree Architecture." Pumpkin and Apple Twilight Meeting, Keedysville, MD. Walsh, C.S. and J. Harshman. 24 Sept 2009. (attendance 52).

"Which Rootstock to Use with Which Variety?" Proceedings of MN Apple Growers Association, LaCrosse Wisconsin. Hoover, E., 2009.

"Growing Fruit in Home Gardens." Master Gardener Core Course Proceedings. Hoover, E. Jan. 2009.

"Growing Big Sweet Cherries on Small Trees" Program Speaker, Southwest Hort Days, Benton Harbor, MI, 5 February (2009)

"Growing Big Sweet Cherries on Small Trees" Program Speaker, Hart-Shelby Extension Meeting, Hart, MI, March (2009)

"High Tunnel System and Orchard Design Factors for Sweet Cherry Production" American Society of Plasticulture, College Park, PA, July (2009)

North Jersey Fruit Meeting, Broadway, NJ March 2009. (67 attendees)

North Jersey Twilight Fruit Meeting, Rutgers Snyder Farm, Pittstown, NJ. April, 2009. (46 attendees)

North Jersey Twilight Horticultural Research Meeting, Rutgers Snyder Farm, September, 2009. (attendance 54)

"Rootstocks and Orchard Densities for the Southeast," Blue Ridge Apple Growers Meeting. 11 Feb 2009. (attendance 100)

"Apple Rootstocks and Replant Strategies for NC Growers," Brushy Mountain Fruit Growers Meeting, 26 Feb 2009. (attendance 40).

"Evaluation of potential new size controlling rootstocks," 2009 North Coast Pear Research Meeting, 11 February 2009 (attendance 32)

Refereed publications

Rootstock studies

Autio, W. T. Robinson, W. Cowgill, C. Hampson, M. Kushad, R. P. Quezada, R. Perry, and C.R.Rom. 2008. Performance of "Gala' Apple trees on Supporter 4, P.14, and Different Strains of B.9, M.9, M.26 Rootstocks: A Five-Year Report on the 2002 NC-140 Apple Rootstock Trial. J. Amer. Pom. Soc. 62(3): 119-128.

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Marini, R.P. B. Black, R.M. Crassweller, P.A. Domoto, C. Hampson, S. Johnson, K. Kosola, S. McArtney, J. Masabni, R. Moran, R.P. Quezada, T. Robinson, and C.R. Rom. 2009. Performance of 'Golden Delicious' apple on 23 rootstocks at 12 locations: A five-year summary of the 2003 NC-140 dwarf rootstock trial. *J. Amer. Pom. Soc.* 63:115-127.

Okie, W.R., G.L. Reighard, and A.P. Nyczepir. 2009. Importance of Scion Cultivar in Peach Tree Short Life. J. American Pomological Society 63(2):58-63.

Oliver, J. E., J. Freer, R. L. Andersen, K. Cox, T. L. Robinson, and M. Fuchs. 2009. Genetic Diversity of *Prunus necrotic ringspot virus* Isolates Within a Cherry Orchard in New York. *Plant Disease* 93:599-606.

Olmstead, M.A., N.S. Lang, and **G.A. Lang**. 2009. Carbohydrate profiles in the graft union of young sweet cherry trees grown on dwarfing and vigorous rootstocks. *Scientia Hortic*.:accepted.

Reighard, G.L., D. R. Ouellette, and K. H. Brock. 2008. Performance of new *Prunus* rootstocks for peach in South Carolina. Acta Hort. 772:237-240.

Robinson, T.L. 2008. Performance of pear and quince rootstocks with three cultivars in four high density training systems in the Northeastern United States. *Acta Hort.* 800:793-801.

Related fruit publications

DeEll, J., P. Toivonen, S. Khanizadeh and C. Hampson. 2009. Browning potential of new apple varieties. Acta Hort. 814:529-531.

Hampson, C. R., R. McNew, J. Cline, C. Embree, J. Zandstra and K. Wilson. 2009. Regional differences in performance of Canadian-bred apple cultivars and implications for breeding. Can. J. Plant Sci. 89:81-91.

Hampson, C., H.A. Quamme and P.L. Sholberg. 2009. A study of scab resistance in 16 apple progenies using parents with partial scab resistance. Can. J. Plant Sci. 89:693-699.

Lang, G.A. 2009. High tunnel tree fruit production – the final frontier? HortTech 19(1):50-55.

Mulabagal, V., G.A. Lang, D.L. DeWitt, S.S. Dalavoy, and M.G. Nair. 2009. Anthocyanin content, lipid peroxidation and cyclooxygenase enzyme inhibitory activities of sweet and sour cherries. J. Agric. Food Chem. 57(4):1239-1246.

Robinovich, Adriana. 2009. Studies on Apple Peel Color Regulation. Ph.D. Thesis. University of Minnesota.

Telias, A., E. Hoover, D. Rother. 2008. Plant and Environmental Factors Influencing the Pattern of Pigment Accumulation in Honeycrisp Apple Peels Using a Novel Color Analyzer Software Too. HortScience 43:1441-1445

Toivonen, P.M.A. and C. Hampson. 2009. Apple cultivar and temperature at cutting affect quality of fresh slices. HortTechnology 19(1):108-112.

Non-refereed 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. 2009. Pest management guidelines for commercial tree-fruit production 2009. Cornell University, Ithaca NY 252 pp.

Autio, W., and J. Krupa. 2007. Final report from the 2002 NC-140 Peach Rootstock Trial. Fruit Notes 72(3):8-10.

Autio, W. and J. Krupa. 2008. Are the effects of crop load altered by rootstock? An update on the 2003 NC-140 Apple Physiology Trial. Fruit Notes 73:7-9.

Autio, W., J. Krupa, and J. Clements. 2008. Comparing McIntosh apple trees on several Geneva and Supporter rootstocks: An update on the 1999 NC-140 Dwarf Apple Rootstock Trial. Fruit Notes 73:10-11.

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Autio, W., J. Krupa, and J. Clements. 2008. Comparing Gala apple trees on different strains of B.9, M.9, M.26, and other rootstocks: An update on the 2002 NC-140 Apple Rootstock Trial. Fruit Notes 73:14-16.

Cheng, L. and T.L. Robinson. 2009. Honeycrisp leaf chlorosis: Causes and mitigation. *Proc. of the 2009 Empire State Fruit and Veg. Expo.* p. 37-39.

Domoto, P. 2009. 2003 NC-140 Dwarf Apple Rootstock Trial Performance in 2008. Ann. Prog. Rept. – 2008 Hort. Res. Sta., ISRF08-36:27-29. http://www.ag.iastate.edu/farms/08reports/Horticulture/DwarfAppleRootstock.pdf

Elkins, R. and C. Ingels. 2009. Evaluation of potential new, size controlling rootstocks for European pears. 2008 Calif. Pear Research Reports. p. 85-90.

Pokharel, R. and Larsen, H. 2009. Evaluation of apple rootstocks planted in high pH soil. 2008 Annual Report of the Western Colorado Research Center, Colorado State University.

Robinson, T.L. 2009. Improved Apple Orchard Management Systems and Rootstocks for Northern NY. *Northern New York Agricultural Development Program Final Report 2008*. pp 156-170.

Robinson, T.L. 2009. Fertigation of apple trees in humid climates. *Proceedings of In-depth Fruit School on Apple Mineral Nutrition.* pp 53-65

Robinson, T.L. and S.A. Hoying. 2009. Fine points to consider when making planting system decisions. *Proc. of the 2009 Empire State Fruit and Veg. Expo.* p. 1-4.

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Robinson, T.L. and A.N. Lakso. 2009. Predicting and understanding chemical thinner response in real time. *Proc. of the 2009 Empire State Fruit and Veg. Expo.* p. 43-45.

Robinson, T.L. and S. Lopez. 2009. Cropload management for consistent Honeycrisp apples. *Proc. of the 2009 Empire State Fruit and Veg. Expo.* p. 40-42

Robinson, T.L., R.L. Andersen and J. Freer. 2009. Promising new rootstocks for cherries, peaches and plums. *Proc. of the 2009 Empire State Fruit and Veg. Expo.* p. 10-13.

Robinson, T.L., S.A. Hoying and R.L. Andersen. 2009. Growing High Density Sweet Cherries in the East. *Ohio Produce Growers and Marketers Association Today* Fall issue p.3-5.

Robinson, T.L., A.N. Lakso, and S.A. Hoying. 2009. Chemical thinning and return bloom of apple. *Ohio Produce Growers and Marketers Association Today* Summer issue p.4-6.

Robinson, T.L., S. Lopez, K. Iungerman, and G. Reginato. 2009. Cropload and nutrition affect Honeycrisp apple quality. *Proceedings of In-depth Fruit School on Apple Mineral Nutrition.* pp 87-95.

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Robinson, T., M. Miranda-Sazo, C. Kahlke. 2009. Suggestions for use of Retain on apples in WNY. Lake Ontario Fruit Newsletter 2009(17):6-8.

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Walsh, C.S. 2009. Apples: Growing disease resistant cultivars in the Mid-Atlantic. *Washington Gardener.* September/October issue: 19-21.

Wolfe, D.E., and J.G. Masabni. 2008. Rootstock and Interstem Effects on Pome Fruit Trees. 2008 Fruit and Vegetable Crops Research Report. University of Kentucky College of Agriculture, Agricultural Experiment Station publication PR-572:31-33.

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Harshman, J.M, C.S. Walsh, J. Daberkow, K, Sparks, M.J. Newell and G.R. Welsh. 2009. Hybridizing 'McIntosh Wijcik' and heat-tolerant apple cultivars to develop precocious seedling trees with improved tree architecture. *Acta Hort.* (In press).

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Rom, C.R. 2009. Crop Load Management in Tree Fruits: A Perspective. In, Miller, S. (Ed.) Regulation of growth and cropping on fruit trees. International Fruit Tree Association in conjunction with the Good Fruit Grower Press (in digital publication).

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crop load on ‘Honeycrisp’ fruit quality. *HortScience* 44:1011-1012 (Abstr.).

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Appendix: Individual State Accomplishments and Impacts in 2009

Alabama

As part of the NC140 2009 Peach Rootstock Trial, a new planting of 14 rootstocks were established at the Chilton Research and Extension Center, Clanton, AL with the 'Redhaven' as the scion. The trial planting included eight replications in a randomized complete block design. Tree growth was very good during the 2009 season. In the fall of 2009 measurement were collected to determine differences in trunk circumference, number of root suckers and survival rate as per the project protocol. Additionally, a visual rating to assess differences in plant vigor impaired by the rootstock type was conducted late in the season. Information on rootstock performance will assist us in making recommendations to growers.

A second planting was established in 2009 at the same location in Alabama. Eight single tree replications each of the peach cultivars 'Crimson Lady', 'Cresthaven' and 'Redhaven' were planted as part of the 2009 Peach Physiology study. All measurements were collected according to the study protocol.

Arkansas

All apple rootstock trials are conducted at the Main Experiment Station, Fayetteville (FAY). The peach rootstock physiology trial is located at the Fruit Research Station, Clarksville, AR. The 2009 season was a very difficult year for both research and commercial fruit growers. In late January, a sever ice storm occurred in the region which caused significant tree damage. Because of a cool winter and a warm late winter/early spring, bloom progressed more rapidly than average and field plots bloomed 5-7 days earlier than normal. During the full bloom period there was a severe late frost of -5C that caused significant blossom damage. Weather during the bloom season was very cool, cloudy and exceptionally wet and pollination conditions were poor. All trials had very poor to no fruit set due to the combination of frost and pollination conditions.

Objective 1. Rootstock and Management System Evaluation.

Apple Rootstocks. Four project related trials are in progress: 1) the *2002 'Gala' Dwarfing Rootstock Trial*:(Table 1); 2) the *2003 'Golden Delicious' Physiology Trial*: (Table 2), 3) the *2003 'Golden Delicious' Dwarfing Rootstock and Physiology Trial* (Table 3), and 4) the 1999 Arkansas Rootstock (AAR) Trial (Table 4).

There was no crop in 2009 due to a combination of frost and poor pollination conditions. All uniform apple rootstock trials were concluded and removed in 2009 due to lack of fiscal support to manage the NC140 plots.

Peach Rootstock/Physiology Trial: Trees were planted on March 18th 2009 at the Fruit Research Station in Clarksville, AR. The planning consists of 10 blocks with 8 of the blocks having all 3 cultivars (Redhaven and Cresthaven, and Crimson Lady). The other two blocks have Redhaven and Cresthaven only. These trees were planted six between trees and 18 feet between rows. Nitrogen fertilizer was applied in April at 0.02 lbs actual N (according to UACES Fertilizer Recommendations Manual). Second fertilizer application was made on May 28th. Tree training on an 'open center' began in June. Pest management practices followed UACES recommendations.

California

In the 2003 Golden Delicious apple planting the rootstocks that maintained tree vigor in the range of M.9 to M.26 and also had high yield efficiency were CG.5179, CG.5935, G.16 and J-TE-H. CG.4210 made a little larger tree but has been very productive with reasonable fruit size the last 2 seasons. The 2009 Redhaven peach rootstock trial was established in March and the

trees grew very well. Trees of Redhaven, Cresthaven and Crimson Lady on Lovell rootstocks were also established in this block for future physiology studies. In the North Coast location of the 2005 Bartlett pear planting, Horner 4 had the most and largest fruit and the highest yield, nearly twice the average of all the other rootstocks but yield efficiencies were equal among all rootstocks. For the Sacramento Delta location, Fox11 yielded the most and BM 2000 the least. Finally, in the 2005 Golden Russet Bosc trial OHxF 87 yielded the most and Fox 11 and BM 2000 the least.

Canada (British Columbia)

In general, tree health/survival on JM1, JM7, JM8 and G.16 has been lower than desirable for commercial usage

Trees on JM2, P14, Supporter 4, PI5683, PI514 and JM2 appear to be larger than the size desired for local high density plantings. Trees on JM1 and JTEG were too small for our uses. Several rootstocks with vigor in the M.26 and M.9 size classes and equal or better productivity have been tentatively identified (CG6210, JTEH, PI5111, JM7, G16, CG5935, CG3041, V2, V3, B62396). Some of them have detractive features (more tree deaths, more root suckers) but others are very interesting and some are reportedly resistant to fire blight.

A new trial was planted in spring 2009 of apple rootstocks from Quebec plus two standards (M.9 and B.9). The new ones are: SJM-15, SJM-189, SJP84-5198, SJP84-5218.

Canada (Nova Scotia)

The following plantings are still in place: 1984 planting, 1989 NC-140 pear rootstock planting, NC-140 1992 Liberty/Cornell rootstock planting, 1999 Cornell Geneva Dwarf and Semidwarf rootstock planting (removed in 2008 and data submitted), 2005 Pyrodwarf pear rootstock trial, and 2006 replant study. There were no particular outstanding tree losses or effects that should be highlighted, other than the large number of root suckers on the Pyrodwarf pear rootstocks. One tree had 133 root suckers. An own-rooted Honeycrisp was established in 2009 from tissue culture, propagated trees. Plans are to remove the 1984 apple rootstock in 2010 following root profile evaluations, tree weights, etc.

Colorado

Colorado currently has three ongoing rootstock evaluation studies. In the 2008 apple rootstock study, Brookfield Gala on rootstocks G.65, 6143, and 5087 had the least growth in circumference (1.4, 2.0, and 2.0 cm, respectively) while the same scion on rootstocks GC 7707, Naga, JTE-B and Maruba had the greatest growth (3.75, 3.8, 4.2, and 4.2 cm, respectively) during year 2. Study 2 is an evaluation of interactions between Bing cherry on different cherry rootstocks in the discontinued 1998 NC-140 cherry rootstock trial, Cherry Rasp Leaf Virus and its dagger nematode vector. Cherry Rasp Leaf Virus symptoms were observed in the planting in 2007; trees were reevaluated for virus infection symptoms in 2009, and symptoms were found only in trees on Mazzard, Mahaleb, Edabriz, W10, W13, and W158rootstocks. Surveys of soils from beneath these trees for associated plant parasitic nematodes over the following 2 years found the dagger population in this block is more than enough to transmit the virus. Soil from beneath symptomatic trees (assumed to have such viruliferous dagger nematodes) was introduced beneath non-symptomatic trees in summer of 2009. Observation of virus symptoms in this block will be continued. Study 3, a peach rootstock trial with Redhaven peach on 17 different rootstocks, was planted in 2009. In October 2009 (end of year 1 growth), *Prunus americanum* and KV010-123 had the least growth (0.57 and 0.60 cm, respectively) while Empyrean ® # 2 PENTA followed by Bright's Hybrid # 5 had the greatest growth (2.56 and 2.47, respectively). Tree mortality was observed for Atlas, Empyrean ® # 2 PENTA, Guardian, Krymsk-86, and Viking rootstocks (one each except Viking which had four dead trees).

Georgia

The 2009 peach rootstock trial was planted March, 2009. Sixteen rootstocks with Redhaven as the scion cultivar were established. Significant deer pressure was observed necessitating the construction of a deer fence around the block. At this time most trees appear to have survived. Data collection will commence shortly.

The 2009 peach physiology trial was planted March, 2009 adjacent to the above peach rootstock trial. The Physiology trial consisted of the scion cultivars Redhaven, Cresthaven and Crimson Lady budded to Lovell rootstock. This trial was planted as guard trees around (a portion of) the perimeter of the rootstock trial. Trees of Redhaven on an advanced rootstock selection from the Byron program were used a guard trees on the remainder of the perimeter. These perimeter trees took the brunt of the initial deer grazing and appear to have suffered some losses. An inventory will be performed shortly.

Iowa

Objective 1: NC-140 2003 Multi-State Apple Rootstock Planting - Iowa continues to participate in the 2003 multi-state apple rootstock trial. Based on trunk cross sectional area, trees have separated into 4 size groupings: PiAu 56-83, PiAu 51-4, PiAu 36-2, JM.5 and JM.2 being the largest and in a semi-vigorous size range; JM.4, CG.6210, JM.8, PiAu 51-11, M.26, J-TE-H CG.5935 and JM.10 in the M.26-size range; Bud.62-396, CG.5179, JM.7, JM.1, M.9 Pajam2, M.9 T337, G.16 and CG.3041 in the M.9-size range; and J-TE-G, and B.9 in the smallest size range (Table 1). On a cumulative basis in each size range, trees on JM.2 in the semi-vigorous size range have been the most productive; trees on CG.5935, CG.6210 and JM.8 have been more productive than trees M.26; trees on CG.3041 and JM.7 have been more productive than trees on M.9 T337; and trees on J-TE-G have been more productive than trees on B.9.

Objective 3: NC-140 2003 Apple Physiology Study -Study was aborted in 2009 because of insufficient blossom clusters to achieve high fruit densities on M.9 and M.26 trees.

Kentucky

The 2009 growing season averaged 0.4 °F lower than normal. The state apple crop was about 60% of normal due to a lighter bloom from the biennial effect of the year following a heavy crop and to poor pollination caused by a cool wet spring. Fruit size was often smaller than desired due to low seed number, though adequately pollinated fruit were of sufficient size. Fruit color was outstanding because of the cooler-than-normal July and August. The 1999 apple trial with 'Fuji' as the scion was terminated at the end of 2008 after collecting data on winter injury. There were no significant differences among either the dwarfing or semi-dwarfing rootstocks with regard to either blackheart injury in the xylem or winter injury on the scions. The % winter injury on the bark of M.9 NAKBT337 and Supporter 4 was significantly higher than that observed for the other rootstocks. In the 2002 apple trial with 'Buckeye Gala' as the scion, significant differences were observed for cumulative yield, 2009 yield, fruit weight, and trunk cross-sectional area (TCSA), but no differences were observed in tree mortality, cumulative yield efficiency, or number of root suckers. The cumulative yield was greatest for scions on P.14 and M.9 Burgmer 756. P.14 and the two B.9 rootstock strains have produced the largest and smallest trees, respectively. In the 2003 apple rootstock and physiology trials with 'Golden Delicious' as the scion, mortality, cumulative yield, 2009 yield, TCSA, and cumulative yield efficiency varied significantly among the rootstocks. The highest cumulative and annual yields were observed on PiAu 56-83, which also had the largest fruit size and trunk cross-sectional area. In the physiology trial, there was no significant interaction between crop load treatments imposed in 2008 and rootstock. However, 2009 yield, fruit weight, and crop density were

significantly affected by crop load treatments imposed in 2008, while TCSA, number of flower clusters per cm^2 of limb cross-sectional area, and cumulative yield efficiency were not affected. Yield and yield/TCSA were positively correlated with fruit/TCSA in 2008, while fruit weight was negatively correlated. In 2009, yield, yield/TCSA, fruit weight, and flower clusters/limb cross-sectional area were negatively correlated with fruit/TCSA treatments in 2008. The 2009 peach rootstock and physiology trials were planted.

Maine

Objective 1. Data was collected on the 2003 Rootstock Trial and Physiology Trial. Trees were in the "on" year, so crop load treatments were established in mid July. Individual fruit weight decreased with increase in fruit density in all three rootstocks. Reduction in fruit size with increase in fruit density appeared to be more severe with M.26 and G.16 than for T.337.

Evaluation of New Apple Rootstocks (local project)

Honeycrisp on G.16 and M.26 were established in four preplant treatments, an untreated control, a mycorrhizal root dip, soil-incorporated compost or both in 2002. Cumulative yield was similar for both rootstocks. The mycorrhizal root dip increased cumulative yield with M.26, but not G.16. Trees planted into compost amended soil had greater cumulative yield than control trees for both rootstocks.

Objective 4: *Cold Hardiness Testing of New Apple Rootstocks (local project)*

Cold hardiness was evaluated in two rootstocks, M.26 and G.41 in February 2009. Following cold storage at 4-5 °C, G.41 commenced growth and probably deacclimated which may have interfered with the testing. G.41 roots were injured by temperatures of -9 °C and colder, whereas, M.26 was injured by temperatures of -12 °C and colder. Significant tree deaths occurred at -18 °C and below with no difference between the two rootstocks.

Massachusetts

Gala trees in the 2002 NC-140 Apple Rootstock Trial performed well in 2009. Largest trees were on PiAu51-4, followed in decreasing size by those on P.14, PiAu51-11, M.26 NAKB, Supporter 4, M.26 EMLA, M.9 Burgmer 756, M.9 NAKBT337, M.9 Nic 29, B.9 (North America), and B.9 (Europe). Greatest yields in 2009 and cumulatively (2004-08) were harvested from trees on PiAu 51-4. Lowest yields in 2009 and cumulatively were from trees on the two strains of B.9. Cumulatively (2004-09), B.9 (North America) resulted in the greatest yield efficiency, while PiAu 51-4 resulted in the lowest. Average fruit size (2004-09) was largest from trees on M.9 NAKBT337 and M.9 Nic 29 and smallest from those on B.9 (Europe).

The crop loads of Golden Delicious trees in the 2003 NC-140 Rootstock Physiology trial were adjusted per the experimental protocol, and tree size and fruit characteristics were assessed at the end of the season. Increasing crop load reduced trunk growth similarly across rootstocks. Fruit weight was negatively related to crop load and was similar across rootstocks. Ripening was delayed by increasing crop loads of trees on M.26 EMLA and on G.16, but trees on M.9 NAKBT337 were unresponsive. Interestingly, starch content and soluble solids concentration were affected oppositely from what would be expected regarding ripening. Clearly, when crop load increased, trees were deprived of adequate energy to produce starch. These fruit initiated ripening with very little starch available to break down into sugars, hence low soluble solids concentration and a high starch index value.

Redhaven trees in the 2009 NC-140 Peach Rootstock Trial grew well in their first season. Trees on Penta, Guardian, Viking, and *Prunus americana* were the largest, and those on Controller 5 were the smallest. From planting to the end of the season, the fastest growing trees were on Guardian, and the slowest were on Controller 5 and *P. americana*.

Mexico (Coahuila)

2006. “Royal Gala” Rootstock x Replant Trial. Trees planted at the Saltillo area were grafted with Royal Gala on eleven rootstocks, including B.9, M.9 T337, M.9 Pajam2, M.26, M.7, G.11, G.16, G.30, G.41, G.935 and G.4210. Apple Replant Disease (ARD) problems have been prevalent at the Saltillo fruit growing area. Poor growth and survival are typical of apples replanted into apple ground due to ARD. No differences were observed between the non-fumigated and fumigated treatments. The NC-140 trial is an educational tool for growers in Southern areas to help in their decision making of rootstocks to consider in their high to medium density orchards.

Michigan

The 2009-10 High Density Sweet Cherry Systems trial was established with planting of the guard trees and the sleeping eye treatment trees, and installation of a deer exclusion fence. The main treatment trees (3 rootstocks x 3 systems) will be planted in spring 2010. Related research (UFO, bi-lateral cordon, super slender axe training systems) in existing plots continues to provide guidance for the future protocols for developing fruiting wall canopy architectures. Such systems are being incorporated in high tunnel cherry production research. The current apple rootstock research includes one NC140 trial (2002 ?Gala?, mortality data only) and four elite Geneva rootstock trials with ?Honeycrisp? planted in 2003 (at MSU/Clarksville and MSU/Northwest station) and 2004 (Belding cooperating grower and MSU/Northwest station). In 2009, only a couple of rootstock genotypes equaled or exceeded M.9 for yield efficiency and fruit size in high density training systems, including CG.4202 at Belding and CG.3041 (G.41) at Clarksville. At the Northwest station, quite a few rootstock genotypes exceeded M.7 and MM.106 for yield efficiency, including CG.5757, CG.5257, CG.5046, CG.6143, and CG.5179.

Minnesota

Presently, the University of Minnesota is working on Objective 4 of the project. Specific results for the project include four plantings located in Chanhassen MN at the Minnesota Landscape Arboretum. In the 7th leaf, EMLA.7, V1 and CG30 produced the largest trees and have consistently since the 4th leaf with Honeycrisp as the scion. Honeycrisp fruit size was significantly larger on trees grown on EMLA.7 unlike previous years. In the same planting, CG30 produced the largest yield, not unexpected given the size of the trees, with Bud.9 producing trees with nonvigorous growth and poor yields. We established a rootstock trial in the spring of 2003 with a Minnesota breeding selection MN1914. When grown on Bud.9 a very small tree is produced with few small apples. This rootstock/scion combination is not recommended for production in our climate. Trees grown EMLA.26 produced the largest fruit, with comparable yields to M.9T337. MN1797, now named SnowSweet had excellent tree growth even though moisture was limiting during the 2009 summer. SnowSweet is a late cultivar for Minnesota with fruit harvested October 14 and has a droopy growth habit. SnowSweet on EMLA.7 and V1 produced the largest trees with these two rootstocks producing the largest trees consistently since the 3rd leaf. Bud.9 produced not only the smallest trees but also had the lowest yields in the study. With Zestar! as the scion cultivar, EMLA.7 continues to produce large trees with lower yields than other rootstocks in this trial. Bud. 9 is an interesting rootstock for use with Zestar! as vigor, denoted by trunk cross sectional area, is similar to EMLA.9 but maintains larger average fruit size than EMLA.9. Bud.9 rootstock should be used with fairly vigorous cultivars for maximum fruit production.

New Jersey

New Jersey NC140 trials are located at the Rutgers Snyder Farm, Pittstown, NJ. All data was collected in 2009. Weather was extremely variable in northern NJ for pollination, fruit set and growth throughout the summer. . Fruit quality across the board was significantly reduced with

soluble solids averaging 1-2% Brix lower on average. Many cultivars like the early Fuji group had no taste at all. Some blocks of trees had poor growth due to water logged soils. 2002-NC-140 Apple Rootstock Trial- Rootstock significantly effected TCSA ($p<0.001$) where PiAu51-4 had the highest and B.9 Europe had the lowest TCSA. B.9 notes: Significant differences are showing between B.9Europe and B.9Treco. of deep concern is the extensive burrknots showing on B.9Europe at 50% as compared to B.9Treco at 17% in 2008 data. B.9Europe also had significantly more suckers than B.9Treco in 2009 at 9.1 to 1.4 in 2009. New Jersey/UMASS G.16 Cameo NC140 Rootstock Trial-There were no significant differences in number of root suckers, percent burrknots, yield in 2009 or cumulative yield from 2004 through 2009. TCSA was significantly different ($p<0.001$) by rootstock where B.9 was the smallest and G16 and M.9T337 were significantly larger with no differences between them. B.9 also had the smallest average fruit size ($P = 0.002$) and B.9 had the highest yield efficiency in 2009 ($p < 0.001$) and cumulative yield efficiency ($p < 0.001$).

North Carolina

North Carolina has two of the active NC-140 cooperative plantings. The trials that are currently under investigation in North Carolina are the 2006 apple replant trial and the 2009 peach trial. In the 2006 apple replant trial, across fumigation, there were no significant differences in tree survival among the dwarf and semi-dwarf rootstocks. There were differences in trunk cross-sectional area (TCSA) among the dwarf rootstocks across fumigation treatments with the trees on CG.5935 being the largest and trees on B.9 the smallest. The first crop was in 2008, with a reduced crop in 2009 due to a late season frost/freeze event, and the trees on CG.5935 had the greatest 2009 and cumulative yield, with trees on M.26 having the smallest cumulative yield. Trees in fumigated soil on CG.5935 had a greater 2009 and cumulative yield than trees on CG.5935 in non-fumigated soil. For the trees on the semi-dwarf rootstocks, across fumigation, there was no significant difference in TCSA. However, trees on G.30 had the greatest 2009 and cumulative yield. Overall, across rootstock, trees on fumigated soil had a greater cumulative yield for both the dwarf and semi-dwarf rootstocks. Although early in the life of this study, it appears that soil fumigation may be beneficial for trees planted on some rootstocks. The 2009 peach trial is planted at the Sandhills Research Station in Jackson Springs, NC and consists of 17 rootstocks with Redhaven as the scion cultivar. Soil was preplant fumigated in October 2008 with Telone II. The trees were planted in March 2009 and grew very well in 2009 with no tree loss. There seemed to be quite a bit of variability in tree size and quality at planting, however, in October tree size was quite uniform and vigorous across the planting. Beginning in September the trees on Fortuna began to turn color much sooner than trees on all other rootstocks. There is also an overgrowth of the scion on the rootstocks. However, trees appear to be healthy with no trees loss at this point.

The data collected from this project continues to be an educational tool for growers in the Southeast to help in rootstock selection for high to medium density orchards and is presented at grower meetings and orchard tours to educate our clientele about apple and peach rootstocks. With size-controlling precocious rootstocks, growers are able to change to higher value cultivars much more quickly in addition to the benefits of better economic returns to the grower, reduced labor, and reduced pesticide usage.

Oregon

Two European pear rootstock trials were established at the Mid-Columbia Agricultural Research and Extension Center, Hood River, Oregon: 1) 2002, and 2) 2005. For the 2002 planting, cumulative results over eight years shows significantly higher yields and yield efficiency for ‘d’Anjou’ pear on OHxF 87, Winter Nellis and Pyro 2-33. Fruit size was significantly higher on

OHxF 87 and Pyro 2-33. Among the rootstocks that performed poorly, 708-36 and Fox 11 had nearly half the yield as the top-performing selections, with concomitantly small fruit, and trees on both rootstocks appear to expressing decline-like symptoms. There were no significant differences among any of the rootstocks for 'd'Anjou' trunk size. Trees in the 2005 trial produced their first crop. 708-36 had the highest yields (10 kg per tree). 708-36 has been observed to impart precocity on 'd'Anjou', however, based on performance in the 2002 trial, both in OR and WA, it is likely that production levels will markedly decline over time. Horner 4 had the largest trunk size, without improvements in fruit number.

Pennsylvania

There are four apple rootstock trials at the Rock Springs Research Farm near University Park. After 10 years the TCA of 'Fuji', but not 'McIntosh' trees on Support 1, 2, and 3were statistically smaller than M.9 NAKBT.337 and M.26 EMLA. Cumulative yield efficiency was lowest for M.26, but differences were significant for only 'McIntosh". In another trial with 'McIntosh', trees on Supporter 4 had TCA and yield efficiency intermediate between M.7 and M.26. In the 2003 'Golden Delicious' uniform rootstock trial, the smallest trees were on M.9 T337 and J-TE-G. The largest trees were on JM.2. Cumulative yield (2005 – 08) has been greatest on PiAu 51-4 and least on J-TE-G. Cumulative efficiency has been least for trees on JM.2 and greatest for trees on J-TE-G. A planting was established in 2007 with the scion 'Crimson Gala' to evaluate many of the new Cornell Geneva rootstocks that are available commercially. Rootstocks in this planting include G.65, CG.4210, CG6210, G.935, G.041, M.9T337, B.491 and Ottawa 3. At the end of 2008 the largest trees as measured by TCA were on G.935 and the smallest were on CG.4210. The number of flower clusters and consequently bloom density was greatest on trees on G.041 and only G.65 had no flowers this past season.

South Carolina

The 2009 NC-140 peach rootstock trial was established near Clemson, South Carolina. Eighteen rootstocks with Redhaven as the scion cultivar were planted, and all trees survived the summer except for one scion on *P. americana*. This tree root suckered and Redhaven was rebudded to it. Most trees from the nursery arrived in good shape except those on *P. americana* and Guardian®. The *P. americana* trees were shipped from a different nursery and though the scions were of large caliper, the scion buds mostly aborted after planting due to a likely cold storage problem. The Guardian® trees had excellent seed germination but the nursery forgot to thin out the seedlings in the nursery; thus leading to restricted space to grow out and small caliper trees. By October, every tree on Fortuna was showing a scion overgrowth and off-color foliage. Adjacent to this planting, the 2009 NC-140 peach physiology trial was planted with the scion cultivars Redhaven, Cresthaven and Crimson Lady, all budded to Lovell rootstock and replicated 8-10 times.

Utah

The 1998 Tart cherry trial and the 2001 peach trail were both removed, and destructive sampling carried out to determine root distribution pattern and above-ground biomass. Results of this sampling was prepared and submitted for publication in the Journal of the American Pomological Society.

The 2003 Golden Delicious rootstock and physiology trials continue to suffer the effects of the 2008 fire blight outbreak with both M.9 clones and EMLA.26 showing the highest tree loss.

An independent study was initiated in 2007 to compare alkalinity tolerance of 12 peach rootstocks, with 'Lovell' included as the industry standard. Standard commercial applications of iron chelate were withheld through the 2008 and the first half of the 2009 season. At this point, many of the Lovell trees were either showing severe chlorosis or had died, and a late summer

application of iron chelate was then made. Leaf chlorophyll content was highest in Julior followed by Paramount and Monegro. Monegro produced the largest trees, followed by Nickels and Garnem. The smallest trees were Lovell, followed by Mirobac and Empyrean 2, among which Mirobac was the only one not showing very low levels of leaf chlorophyll.
The 2009 peach rootstock trial was established at 2 locations in Utah, one at the Kaysville research center and the other at a site in Utah County with some salinity and alkalinity problems more representative of some of the marginal commercial acreage.

Wisconsin

The 1998 Cherry and 1999 Dwarf and Semi Dwarf Apple plantings were removed in spring 2009. In the 2003 Dwarf Apple Planting the crop was up from 2008 which suffered from late spring frost and a mid-winter thaw. Yield efficiency (kg fruit / cm2 TCA) ranged from below .50 to just above .90. Among the more efficient rootstocks for the current crop were CG.3041 (0.91), B.9 (0.91) and G.16 (0.77). These three were also smallest trees according to trunk cross sectional area measure. PiAu 56-83 and PiAu 51-4 were the largest trees, among the least efficient for the current season and have the lowest cumulative yield efficiency.
It was a resting year in the 2003 Apple Physiology planting and an effort was made to reduce crop loads below 7 fruit per cm2 TCA. This was done with chemical thinning. Follow up hand thinning should have been performed as not all treatment trees ended up with crop loads as low as we would have liked. Fruit size exhibited a negative relationship to increased crop load.

Funding

Iowa Fruit and Vegetable Growers Association. $1,000

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Patronato para la Investigación Agrícola de Coahuila, Mexico, $2,000

Ing. Humberto Dávila. Huerta El Aguajito, $3,000

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Cowgill, W.P., Jr., 2009. CSRS via NJAES, $5,000

W.Cowgill, J. Clements-USDA SARE grant Apple Testers. $10,000