Accomplishments Report, 2015 NC 140 Project

Impact Nuggets

- The financial benefit to U.S. fruit growers from NC 140 rootstock research findings has accelerated earlier returns, greater yield, and higher fruit quality with a financial impact estimated at $200,000,000 over a 5-year period.

- NC 140 rootstock trials located at research facilities or on grower's farms have yielded invaluable information on adaptability of new rootstocks for apple, pear, peach, and cherry.

- The NC-140 apple and peach rootstock trials are educational tools for growers in the Southeastern U.S. to facilitate decision making of rootstocks to consider in establishing orchards in new and replant sites where peach tree short life decline devastates the industry.

New Facilities and Equipment

Over-the-row mechanical harvesters manufactured by Littau Harvesters were rented and tested for high density tart cherry production systems in MI. Battery-powered hand-held pruners and hedgers were used to impose summer and dormant pruning treatments on sweet and tart cherry in MI. A new orchard of 12 acres was set-up for stone fruit research at the University of Georgia, Griffin Campus, GA. A new fence, irrigation system, two greenhouses and expansion of laboratory space in the upgrade to support fruit research in GA. Sophisticated and modern regular and controlled atmosphere cold storage facilities were built at the University of Idaho Parma Research and Extension Center for our apple project, including several NC-140 projects in 2015. An upgraded apple fruit washing and packing line was installed at the Rutgers Snyder Farm, NJ in 2014. A Bartlett Orchard Chariot platform was purchased in 2015 for PA for use by PSU Ag Bio Engineering and Horticulture projects.

Unique Project Related Findings

Low survival rates by the end of the sixth season were recorded in AL for peach on four rootstocks where all trees on Mirobac and Krymsk®1 rootstocks are dead and low survival on Emperyan@2 and Controller 5, while all trees on Lovell and Guardian are surviving and productive. The 'Controller 8 (HBOK 10)' and 'Controller 7 (HBOK 32)' peach rootstocks, with a smaller overall tree size in comparison with the standards, had similar yield efficiency than the commercial standards. In general the Geneva apple rootstocks are more winter-hardy and disease-resistant in British Columbia, which makes them of great commercial interest for high density apple plantings worldwide. Several Geneva and other apple rootstocks, including Geneva 935 and Geneva 41 seem to be suitable for climate and soil conditions of southwest Idaho. *Prunus americana* as a rootstock for peach continues to be the most productive dwarfing peach

rootstock in a trial in MA, equaling the per-tree productivity of standard rootstocks and producing fruit of comparable size. MD observed good survival of Fuji and Gala apple trees on Geneva rootstocks under local conditions. Evaluation of 3 rootstocks (OHxF 87, OHxF 97 and Pyrodwarf) and 2 pear cultivars (Comice and Concorde) under Nova Scotian environmental conditions demonstrated the need for long establishment times to achieve production. Other cultivars and rootstocks should be sought for the pear industry in Nova Scotia. Spring weather conditions significantly reduced maximum fruit sizes compared to previous years in the Peach Physiology trial in SC likely due to above normal post bloom temperatures.

Accomplishment Summaries

Objective 1. To evaluate the influence of rootstocks on temperate-zone fruit tree characteristics grown under varying environments using sustainable management systems.

Projects in various stages of data collection, evaluation and planning include the following in association with years of plot establishment and identification of trial coordinators:

2003 Apple Physiology (Rich Marini)
2009/2014 Peach Physiology (Rich Marini)
2009 Peach Rootstock (Greg Reighard)
2010 Apple Rootstock (Wes Autio)
2010 Sweet Cherry Rootstock and Training Systems (Greg Lang)
2013 Pear Training/Rootstock/Spacing (Todd Einhorn)
2014 Apple Rootstock (John Cline)
2015 Organic Apple Rootstock (Terence Robinson)

Future plantings for all crops for 2017 and beyond, are in various stages of planning at this time.

Apple Sub-Committee (Chair, Stefano Mussachi, WA)

The 2010 Apple Rootstock trial was established at 13 locations with Honeycrisp and six locations with Fuji. It includes 28 Budagovsky, Cornell-Geneva, and Pillnitz rootstocks and three commercial controls. After five growing seasons, largest trees were on B.70-20-20; the smallest were on B.71-7-22. Greatest cumulative yield were from trees on CG.4004; the least from trees on B.71-7-22 (Honeycrisp) and B.7-20-21 (Fuji). Most cumulatively yield efficient trees were on G.11 and G.4003 for Honeycrisp and on B.9, G.935N, and M.9 NAKBT337 for Fuji. The largest fruit on average were from trees on B.64-194 for Honeycrisp and from trees on G.41TC for Fuji. Trees on PiAu 9-90 continue to have severe chlorosis in BC, a sickly appearance, and often small fruit size. The 2014 Apple rootstock planting was established in 15 locations in the United States (AL, ID, IN, MA, ME, MI, MN, GA, NJ, NY, PA, UT, VA, WA, WI), two in Canada, and one in Mexico (http://bit.ly/1zv3wCc). The trial consists of the following rootstocks: B.10, G.11, G.202, G.214, G.30, G.41, G.5890, G.935, G.969, M.26 EMLA, M.9 T337, V.1, V.5, V.6, V.7. The trial is being coordinated by John Cline who has also

agreed to analyze the data. This trial has two cultivars: Aztec Fuji (AL, ID, GA, NJ, ON, PA, UT) and Honeycrisp (ID, IN, MA, ME, Mexico, MI, MN, NJ, NY, Ontario, PA, VA, WA, WI), planted to a 'tall spindle' systems at a 5 x 12 feet, and 4 x12 feet spacing, respectively. Trees are planted using a randomized block design with single trees serving as experimental units. Each site selected a pollinizer variety since some sites are very limited in adapted varieties. Trees were established in the spring of 2014. The trees were propagated by Willow Drive Nursery, WA. Data protocols have been established for 2014 and 2015. This is a young trial with no significant findings being reported at this time. The 2015 Organic Apple Rootstock Trial, was established in 2015 in 13 US and 1 Mexican state and will evaluate 9 Geneva rootstocks and M.9 NAKBT337 as a control. All trees are managed organically and trained as Tall Spindles. Modi is the cultivar and Liberty is the pollinizer. The design is five blocks in two-tree sets and will require 1/10 acre. Organic certification is optional, but orchard management must be organic. There are no results to report as yet.

Cherry Sub-Committee (Chair, Greg Lang, MI)

The 2010 Sweet Cherry Rootstock x Canopy Training System Coordinated Trial began with 13 sites; these have diminished to 5 due to diseases, cooperator retirements or transitions, deer damage, etc. Sweet cherry performance has varied widely by site and scion cultivar in on-going coordinated trials examining diverse canopy architectures matched with rootstocks of varying vigor levels. Work has begun on the first trial paper (Training Systems Establishment, Years 1-4) with adequate data expected from CA, MI, NY-Geneva, NY-New Paltz, NS, and BC. Since most training systems under test are new and novel, information about proper training and pruning is being developed respect to tree spacing and the range of rootstock vigor in the trial – in some system x rootstock combinations, excessive shading may be causing yields to diminish.
Gi3 combined with Upright Fruiting Offshoots system was insufficiently vigorous for 1.5 x 4 m spacing in British Columbia. Conversely, trees on Gi6 trained to the SSA system in Michigan has been overly vigorous at 0.75 m x 3.5 m. Two 2010 Tart Cherry Rootstock x Canopy Training System Independent Trials were established in UT and MI. The focus is on examining rootstock x canopy training interactions to develop hedgerow-type trees for over-the-row mechanical harvest. Gi.3 was about equal to Gi.5 in adaptability, which were better than Gi.6 and all were better than Mahaleb or Montmorency on its own roots. Yield in 2015 at MI was not recorded due to severe spring frost. For the 2017 Tart Cherry Rootstock x Harvest System trial, Greg Lang has organized tree procurement and will coordinate the trial, which will have 5 Michigan State rootstocks, 3 Gisela stocks (3, 5, 12), Krymsk 6, and Mahaleb. Trial sites are UT (2), WI (2), ON, MI, and NY. The tart cherry trees will be trained for over-the-row mechanical harvesting. The 2017 Sweet Cherry Rootstock trial, coordinated by Greg Lang (MI), will have 5 Michigan State rootstocks, 3 Gisela stocks (3, 5, 12), Krymsk 6, and MxM14. Trial sites include OR, CA, WA, ID, MI, NY, and BC with Benton as a scion. Trees will be trained as 2 or 3 systems at each site. MSU-developed cherry rootstock selections exhibit vigor reduction and precocity comparable to Gisela 3 and Gisela 5 rootstocks for tart and sweet cherry scion varieties in preliminary trials in WA and MI. Preparations have begun to include these in 2017 NC140 coordinated comparative trials for high density sweet and tart cherry production.

Pear Sub-Committee (Chairs, Todd Einhorn, OR; Rachel Elkins, CA)

The 2013 pear training/rootstock/spacing trial coordinated by Todd Einhorn was designed to evaluate the main effects and interactions among rootstock (OH×F 87, OH×F 69 and Pyro 2-33), training system (single axe V, single axe tall spindle, bi-axe vertical), and intra-row spacing (3, 4.5 and 6 ft.) on pear production. Cooperators are OR (Anjou), NY (Bosc), and CA (Bartlett). Across all sites, trees were smallest on Pyro 2-33 and of similar size on OHxF69 and OHxF87. Individual leaders of bi-Axis trees were significantly smaller than leaders of single axis trees at all sites. Anjou tree size was positively related to in-row spacing. For Bosc (NY) and Bartlett (CA), tall spindle produced the highest yields; Anjou (OR) has not yet begun to crop, but flowering was highest for bi-axis trees. T. Einhorn is coordinating a 2018 rootstock trial to evaluate dwarfing potential and productivity of cold-hardy quince accessions on pear. Cooperators include OR, Nova Scotia, NY, PA, and WA. Ten to 14 genotypes presently in tissue culture will be propagated in 2016 and delivered to a nursery for propagation. Rootstocks will be budded to select scions, with and without interstems. OH×F 87 will serve as the control.

Peach Sub-Committee (Chairs, Greg Reighard, SC; Rich Marini, PA)

Five-years of data were summarized for the 16 locations of the 2009 peach rootstock trial. Data was analyzed with a first draft manuscript currently in preparation. Fourteen locations provided data for the 5-year report. *Prunus persica* rootstocks had the highest survival with 5 of the 6 cultivars having 93% or greater survival across all sites. Root suckering was only a problem with *P. americana*, which had excessive root sprouts under the trees. Largest trees were three *Prunus* x almond hybrids and Guardian®. Fruit size varied with location and crop load (i.e., some rootstocks had few fruit). KV010127 produced the largest fruit and Controller 5 and Mirobac (a.k.a Replantpac) the smallest fruit across all sites. Cumulative yields were generally highest with the peach rootstocks with Guardian® leading the way. Lowest yields were from plum hybrids and species. Cumulative yield efficiency was highest on the non-peach rootstocks including many of the plum hybrids or species. However, many of these rootstocks produced trees much smaller than the peach and almond hybrid cultivars. These data suggest there were no demonstrated advantages to using clonal interspecific *Prunus* hybrids for peach production under current cultural practices. The 2009 Peach Physiology Trial is focusing on the interactive effects of early-season temperature, cultivar and crop density on average fruit weight. Five cooperators (AL, ID, MD, SC, and KY). Trees were thinned early in the season to develop a range of crop densities and days from bloom to harvest, average fruit weight and growing degree days. In general, for a given crop density, fruit weight was highest in SC and lowest in KY. Data from other cooperators has not been submitted as of this writing.

Objective 2. To develop improved rootstocks for temperate-zone fruit trees using state-of-the-art genomic tools in breeding programs.

A cherry rootstock selection program (based on sour cherry scion breeding efforts) at MI has identified 5 elite genotypes, Cass, Clare, Lake, Crawford, and Clinton, that confer significant vigor control, precocity, and high productivity to sweet and tart cherry scions. These are being propagated for future NC140 coordinated trial evaluation as well as trials with selected scientists

and growers. In 2014 the Geneva, NY apple rootstock program released one new rootstock, G814. This rootstock has been tested as CG4814. It was evaluated in the 1999 McIntosh semidwarf trial where it was the most efficient semi-dwarfing stock. It has been trialed in a large WA state trial which led to the decision to release this stock at the request of some nurseries for use with Gala. A non-profit foundation (Improving Perrenial Plants for Food and BioEnergy or IPPFBE) based in Richmond, Utah has collected a wide range of fruit tree germplasm, including some *Prunus* material (peach/nectarine, apricot, almond). This material is being donated to USU with funding to support rootstock research. A new breeding program was initiated in June 2015 at WA (WSU) with a focus on producing dwarfing precocious rootstocks for pear.

Objective 3. To accelerate adoption of new rootstocks (a) by improving propagation techniques and (b) by acquiring new rootstocks from worldwide sources.

Discussions, led by MI, are on-going to assist in the importation and propagation of several cherry rootstocks, from Germany known as the WeiGi series. These stocks will be tested in future NC 140 cherry rootstock trials. Three Amelanchier rootstock genotypes were developed from intra- and interspecific hybridization (Germany) and tested in two plantings in Hood River, OR using 'D'Anjou' as the scion and compared to OH×F 87. Trees were established in a rootstock trial in OR on Amelanchier, which have been found to be are highly dwarfed (i.e., half the size of those on OH×F 87). Amelanchier rootstocks conferred high productivity to 'D'Anjou' resulting in ~60 flower clusters and 20 fruits per tree, a 6- and 10-fold increase over OH×F 87 for these factors, respectively. The propagation of several Geneva, NY rootstocks has been improved significantly by the use of tissue culture plants as mother plants for stoolbeds, especially with G.41. This has resulted in an accelerated planting of Geneva 41 stoolbeds. We estimate that 150,000 feet of stoolbeds of G.11 and G.41 and about 50,000 feet of G.935 have been planted. This has resulted in a production of 1.0 million liners of G.11 in 2014 and 1.5 million liners of G.41. Rootpac 20 (Densipac) and Rootpac 40 (Nanopac) from the Spanish Company Agromillora Iberica were obtained by SC for the planned 2017 Peach Systems Trial. Potential new Pyrus seedling rootstocks are being propagated through tissue culture to enable small scale testing of dwarfing capability at WA. Several potential new Pyrus rootstocks were imported from the Musacchi program in Italy to the CPCNW, WA. Once through quarantine and virus testing, these will be propagated for trial.

Objective 4. To better understand the impacts of biotic and abiotic stresses on scion/rootstock combinations in temperate-zone fruit trees.

Biotic stresses. Nutrient acquisition and partitioning to foliage in 'Honeycrisp' apple was examined in 2014 across the range of rootstocks in the 2010 NC140 trial in MI. One aspect of this study is the comparison of 2014 leaf nutrient values with bitter pit incidence ratings in 2013 and 2015. The majority of *P. persica* rootstocks were found to have survival rates above 75% in GA after five years of establishment, which are comparable to the standard rootstock 'Guardian'. Prunus hybrids and other *Prunus* species of rootstocks are not surviving in GA. For peaches grown in the Sandhills region of NC, fumigation is strongly encouraged to minimize the potential for peach tree short life, even when Guardian is used. *Prunus* rootstocks that had *P. dulcis* or *P. domestica* in their lineage have had poor survival in SC, but no rootstocks of 100% *P. persica* have died. It appears that soil fumigation may be beneficial for apple trees planted in

replant sites in NC or the best alternative would be to select alternative rootstocks, especially in not using M.7 in replant sites. In the spring of 2015, 12 plants of two scion varieties, Honeycrisp and Gala, were grafted onto 4 rootstocks (G890, G41, Bud-9 and M9-T337) to study uptake of calcium and nitrogen in WA.

Abiotic stresses. Water relations measurements in the 2015 growing seasons in BC indicated that sweet cherry trees on Gi3 rootstock had lower midday stem water potential than Gi5 and Gi6 rootstocks, suggesting a possible limitation to production. As in previous years, Gi3 was more susceptible to colonization with root lesion nematodes than Gi5 and Gi6 trees in 2015. No bacterial canker was found. Quince selections, with eventual use as rootstocks, are being assessed for cold hardiness in OR. Following a 3-year evaluation of cold hardiness on a subset of 60 quince taxa from the USDA- NCGR core collection (Einhorn and Postman, manuscript in preparation), 22 accessions showed less than 50% browning at -30 °C with no detectable differences in acclimation or de- acclimation relative to pear standards. Twelve of these accessions were micropropagated (2014) and grafted to 'Bartlett' and 'D'Anjou' (with and without interstems) in 2015. Trees will be finished in 2016 and established in Hood River, OR in 2017. In the 2010 Apple Rootstock trial, NS reported a significant delay in harvest this past year due to the weather. Warmer temperatures at night have resulted in delayed coloring of the fruit. Harvest using the dA meter showed wide variation compared with other years. Graft union strength of Geneva rootstocks G. 41, G.935 and M.9 is being studied in UT and NY. A non-profit foundation (Improving Perrenial Plants for Food and BioEnergy or IPPFBE) based in Richmond Utah has collected a wide range of fruit tree germplasm, including some *Prunus* material (peach/nectarine, apricot, almond). A portion of these are growing under high salt conditions, and the apricot germplasm is showing dramatic differences in susceptibility to salt injury. This material along with some funding for characterization was recently donated to USU.

Objective 5. To enhance the sustainability of temperate fruit farming through development and distribution of research-based information utilizing eXtension.

The NC-140 web site, http://nc140.org continues to be our primary outreach component serving as an important collaboration tool for cooperators. Members of the research group communicate through a list serve, and upload/download project files to password-protected directories (NJ, MA). We have used the site to allow for easier collaboration and comparison of replicated rootstock trials. Requirements for web page design for regional projects have been met as outlined by the NIMMS and the North Central Regional Association of Agricultural Experiment Station Directors (NCRA). Articles, photographs and reports were archived throughout the year. Members of our research group have been working on making research-based information available to anyone who would like to use it through eXtension (MN, PA, MA, NY, NC, MO, OH, WV, IN, VA). eXtension is not used in Canada . The database has been completed for apple rootstocks and cultivars and can be viewed at http://www.extension.org/apples. This project was funded through the USDA-SCRI program and was completed in August 2014. We have linked to the primary website for the research group, www.nc140.org. NC-140 also maintains its own Email distribution list for internal communication. The posting Email address is nc140@virtualorchard.net. Reports, presentations, and videos that update NC140 cherry, apple, and stone fruit rootstock research and extension at MI are regularly posted on www.cherries.msu.edu, www.apples.msu.edu,

www.hrt.msu.edu/greg-lang, and www.giselacherry.com. These have been cited by fruit growers throughout the United States around the world as valuable sources of information for new orchard planning and production. The Penn State Tree Fruit Website was upgraded with the addition of several posts on cultural practices including information on apple rootstocks, apple cultivars, training systems, calcium nutrient management and Honeycrisp management.

Impact Statements

Apple rootstock trial coordinator, Richard Marini, Penn State University, used data from the 1994 and 2003 apple rootstock trials to predict and determine rootstock vigor classification. In general, the very vigorous rootstocks differ from non-vigorous rootstocks within 4 years and M.9 can be separated from M.26 in 7 to 8 years. In future NC-140 apple rootstock trials, we should be able to accurately classify rootstock vigor after six or seven years at most locations. This finding will shorten costly field evaluation time to assess rootstock vigor across locations or regions.

Peach tree short life is one of the major concerns and limitations in the southeastern U. S. An NC 140 rootstock trial established in the Sandhills region of NC will demonstrate the best rootstocks to cope with this malady. Data generated in this trial identifies several which are not suitable for eastern NC peach growers and several that may be promising for higher density plantings.

The uniform apple rootstock trials in MN have allowed growers in USDA hardiness zone 4 to evaluate new rootstocks for planting in commercial operations. This information can also be extended to a larger audience via eApples. This information provides scientist members from other regions of NC 140, incite regarding potential cold hardiness of rootstock candidates.

In MA, 200 acres of trees were planted on dwarfing rootstock occurred during 2015 based based on results of NC-140 research. On this acreage, pruning and harvest labor declined by 50%, fruit quality and size increased by 20%, profit increased by 50%, and because of reduced canopy volume, pesticide use declined by 70%.

Other Relevant Accomplishments and Activities

The NC 140 project was awarded the Experiment Station Section Award for Excellence in Multistate Research in 2015. The award was officially presented at the annual Association of Public and Land Grant Universities annual meeting November 14, 2015. The award recognized this regional project's contributions for over 40 years to the fruit growers in North America. NC 140 has been critical to the steady transition to higher density orchards, which has benefited consumers with higher quality fruit at reasonable prices. http://agisamerica.org/september-2015-land-grant-institutions-work-across-state-lines-to-increase-fruit-tree-production/. The project was given a $15,000 stipend to go towards project improvements and scholastic endeavors.