

2015 NC-140 Minutes, Davis, California
Co-Hosted by Rachel Elkins and Ted DeJong, Department
of Plant and Environmental Sciences, UC Davis

Minutes taken by: Rich Marini, Penn State University

Monday, November 2, 2015

Introductions, remarks and introductory business:

Meeting held in room 3001 Plant and Environmental Sciences Building, University of California, Davis. Dr. Helene Dillard, Dean, college of Agriculture and Environmental Sciences welcomed the group. A nomination to approve the minutes of the 2014 meeting was offered by Essie Fallahi and seconded by Susan Blatt and was passed.

Members were introduced, 42 attendees (members and guests).

The first order of business was a discussion of future meeting sites. Greg peck had originally offered to host the meeting in Virginia in 2016, but since he recently moved to New York, Rob Crassweller and Rich Marini offered to host the meeting at Penn State. Peter Hirst motioned to accept the offer and Greg Lang seconded it and the motion passed. There was a suggestion that the 2017 meeting be hosted in British Columbia, but we were informed that Cheryl Hampson will retire soon and Denise Nielson will become the BC representative and she preferred not to host the meeting. Mike Parker agreed to host the 2017 meeting in western North Carolina. Mosbah Kushad motioned to accept the offer, seconded by Matt Stasiak and the motion passed. Chile was suggested as a possible future host. Ron Perry checked on whether or not Chile could host a meeting and was told that it is possible, but the group needed to present a compelling multi-faceted reason to justify meeting outside the U.S.

Dr. Ron Perry, NC-140 Administrative Advisor, thanked the writing subcommittee that developed the successful nomination packet for the national award. Members of the committee included Rich Marini, Wes Autio, John Clements, Win Cowgill, and Emily Hoover. The award will be presented at the November 14 – 15 AUPLU meeting in Indianapolis. The project will get \$15,000 to use to help advance the goals of the project. There was discussion concerning how to best spend the funds and the writing committee will discuss this issue further and make a recommendation. The funds must be spent by September 30, 2017.

Win Cowgill and Jon Clements gave an update on the NC-140 web site. The membership database needs to be updated. Win suggested that we could use some of the award funds to make the website more user-friendly and easier to search. There were

suggestions that more rootstock-related information could be put on the website, but no one knew who would do it. John Clements finally asked “what is the purpose of the website?” Greg Reighard felt that if we include state reports, we should also include a disclaimer.

The next discussion focused on the project rewrite committee because the new proposal is due by December 2016. Mike Parker is chairing the committee and other members include Brent Black, Gennaro Fazio, Greg Lang, Greg Reighard, and Todd Einhorn. The committee was to meet at night to discuss the objectives. The next day the following objectives were suggested:

1. To evaluate the influence of rootstocks on temperate-zone fruit tree characteristics grown under varying environments and training systems using sustainable management practices.
2. To develop improved rootstocks for temperate-zone fruit trees, including breeding, using phenomic and genomic tools and acquisition of new rootstocks from global sources.
3. To investigate physiological processes, biotic and abiotic stresses and scion/rootstock interactions on tree growth and productivity.
4. To integrate and disseminate research-based information that facilitates successful stakeholder adoption of rootstock technologies.

Rootstock trial reports (trial details are in the individual reports)

2003 Apple Physiology (Rich Marini): 3 manuscripts were published in the Journal of APS and the trial is now completed.

2003 Dwarf Apple Rootstock (Rich Marini): Data from the 2003 and 1994 dwarf rootstock trials were used to determine how long it takes to separate rootstocks into vigor classes. In general the very vigorous rootstocks differ from nonvigorous rootstocks within 4 years and M.9 can be separated from M.26 in 7 to 8 years. The manuscript has been submitted to the Journal of APS and will likely be in print by March 2016. He hopes to work on another manuscript for next year: a stability analysis to determine rootstock perform in different locations?

2009 pear Rootstock (Rachel Elkins): There was no report.

2009 Peach Rootstock (Greg Reighard, not present, Mike Parker reports): Five-year data were assembled and analyzed with a first draft manuscript 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 (aka 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.

2009 Peach Physiology (Rich Marini). The original trial was complete two years ago, but four cooperators (SC, ID, KY, MD) have maintained their trees to determine the interactive effects of crop density and early season temperatures on fruit weight at harvest for three cultivars. Thus far, there is a linear relationship between fruit weight and crop density at each location, but the slopes are not all equal. There are not yet enough data points to perform multiple regression and it was agreed that the trial should be continued for the 2016 season.

2010 Apple Rootstock (Wes Autio): Proper protocols for collecting and presenting data were discussed. Wes indicated that the quality of the data is not good and he stressed that proofing the data set before submitting it to him is important. There is a paper on proofing data sets in the NC-140 member's web site. B. 70-20-20 is very vigorous at most sites and the group agreed that it should be removed by cutting the tree off while retaining the roots. This is a very large trial and the experimental design was poor and Wes suggested that we never design a similar experiment in the future. He plans to publish a paper for each cultivar to report the first five years results. Many sites had poor growth and poor survival of 'Fuji' trees and Wes felt that the cooperator should decide if they feel comfortable with the data from these trees before he summarizes the data for publication.

2010 Sweet Cherry Rootstock and Training Systems (Greg Lang): Now that the trees have matured, Greg posted new protocols on the website for training and pruning the trees this year to:

- 1) Optimize light distribution throughout the canopy and minimize shade,
- 2) Promote balanced cropping (reduce the formation of excessive flowers and promote new leaf area), and
- 3) renew at least 15% of the structural fruiting sites.

2014 Apple Rootstock (John Cline, presented by Rich Marini): 14 cooperators for Honeycrisp, 6 for Aztec Fuji. There are 15 rootstocks and 8 sites have 'Fuji' and 14 sites have 'Honeycrisp'. Seven tables of data were included for each cultivar. Several

cooperators indicated that they had damaged 'Fuji' trees from the nursery. Essie Fallahi said he had excellent color but the V-series had mortality from a November cold event. Greg Lang said he had poor fruit color and some sunburn. The Virginia planting was in a grower orchard that was defruited after a hail storm. The grower applied apogee and shut the trees down.

2013 Pear training:/spacing/rootstock trial (Todd Eighorn): the trial is replicated at two sites and there are plans for a five-year paper.

2019 Pear rootstock trial (Todd Eighorn): Cooperators who have indicated interest include Nova Scotia, New York, Pennsylvania and Oregon. There will be two cultivars with and without interstems. At this point Todd has several Quince clones and 15 have been cultured. He is concerned that there is so little information about these rootstocks that it will require a fairly large area. Todd also has some amelanchier, but not enough for a replicated trial.

2014 Organic Apple Rootstock (Wes Autio): There are no results to report as yet, but the trial was established in 13 US and 1 Mexican state. It includes the disease-resistant cultivar, Modi, on nine Geneva rootstocks and M.9 NAKBT337 as a control. All trees are managed organically and trained as Tall Spindles.

Future Trials: There was a discussion about trial leadership. Greg Lang volunteered to coordinate an apricot trial and he is waiting for contact information from Terence Robinson. Stephano Musacchi, (WSU) and Essie Fallahi, (ID) will coordinate future apple trials. There was discussion about the need to develop a plum rootstock trial, but no one wanted to coordinate it.

State and Province Cooperator Reports in alphabetical order

Alabama (Elina Coniva): She has three NC-140 trials, but there were pollination problems with rain at bloom. In the 2009 NC-140 peach rootstock trial Trees on Guardian were most vigorous, Trees on Emperyan^{@2} flowered about four days earlier than trees grafted on other rootstocks in the trial, and trees on Atlas and Controller 5 flowered late in the season. All Mirobac and Krymsk^{@1} trees were dead. Trees on Emperyan^{@2} and Controller 5 also had low survivability (Table 1). All trees on Guardian and Lovell are alive. For the 2014 apple rootstock trial with 'Fuji', trees on V.6 had the most flower clusters and were the most vigorous. Marketable yield of 2.9 kg/tree was also highest for trees on V.6 and lowest for trees on G.202. The highest total number of fruit/tree was on V.7, followed by G.30 and G.969, while trees on G.202 produced the fewest fruit. Trees on V.5 had the most root suckers, while trees on B.10 had no suckers. The 2010 Asian pear trial has 9 Asian pear cultivars and 2 European pear controls.

'Isiiwase' trees were the most vigorous, while 'Hosui' trees were the smallest. 'Olympic' had the highest yield, followed by 'Atago'. 'Shinko' had the lowest crop. 'Olympic' also had the most fruit. "Kosui" had the largest fruit. trees were harvested before optimal fruit maturity in order to avoid further bird feeding loss. This affected the fruit quality results and the fruit firmness was in general high. Sugars were high for Isiiwase, Hosui, and Kosui.

British Columbia (Denise Nielson): BC had an early spring. with Cheryl's retirement she is not sure what will become of the 2010 'Honeycrisp' trial. Denise has the 2010 cherry training system trial and Gi 3 and Gi6 look similar. UFO trees have highest yield but maybe because they are better managed. Fruit weight was high because they did some fruit thinning and the trees may have been under-cropped.

Brazil (Guest: Andrea Rufato, Vacaria (Embrapa)): In 2010 a planting was established with 'Max-gala' on 4 rootstocks trained to the tall spindle form. Trees on G.213 are performing better than trees on M.9 and Marubaide/M.9 interstem. trees on g.213 had better bud break under low chill conditions. Another planting was established in 2014 with 4 Geneva rootstocks.

California (Rachel Elkins and Ted DeJong): The 2005 pear Rootstock trial is completed and the trees are now being used to study water relations. OH87 responded to fruit thinning more than the other rootstocks.

Chile (Felipe Gainza – Dr. Maurico Ortiz): In Chile the emphasis is on stone fruit breeding, genetics, physiology and culture. They have new research facilities. Currently Nemagaurd and Colt are the primary rootstocks for peach and cherry, respectively.

Georgia (Dario Chavez): In the 2009 peach rootstock trial, peach rootstocks have survived better than hybrids or *non Prunus persica* species. Late spring frost may influence the 2015 yield. David Lockwood has the 2014 apple rootstock trial, but data were not yet available.

Idaho (Essie Fallahi): In the 2010 Fuji Trial, B.70-20-20 had small fruit. In the Trees on CG.5087, G.935N, CG.2034, CG.4004 and G.11 were among the most yield efficient yield in kg/ TCSA) and crop efficient (fruit no/ TCSA) ones. Trees on B.7-20-20, B.70-20 and PiAu9-90 were among the least yield efficient ones in 2014.

The 2014 apple rootstock trial consists of both 'Aztec Fuji' and 'Honey crisp' When delivered, the trees were not in optimum condition. Feathers were either dead or broken with severe die back. Trees started to leaf out two weeks late and did not start to grow until mid-summer. These leaves were small and resembled severe zinc deficiency. Trees were fertigated with high rates of zinc and urea to keep them alive and growth improved by the end of growing season. Trees on V.5 and V.6 were more vigorous than those on many other rootstocks. There was a severe and sudden freeze on November 17

and 18, 2014. When temperatures plunged 55 -65 F day time to -5 F at night and caused severe damage on numerous trees and nursery stocks in the region. Most trees on the V-series were damaged. Most trees on "V" series were damaged, but trees grew during June and July 2015, but they finally collapsed during August and September 2015. Although there was not a clear pattern in the damage among rootstocks other than V series, Geneva series seemed to be slightly better than others.

In the 2010 apple tree architecture and rootstock study tree spacing at 3 ft. seemed to be sufficient for trees on Bud 9 but too tight for those on Nic9. Tall spindle with Bud.9 looks good. Yield changed based on the rootstock and tree training system from year to year. Canopies in trees on Nic9 in both tall spindle and central leader trainings were too dense and some fruits did not receive sufficient light to develop good color.

Trees in the 2014 Peach Physiology trial were used for the new peach physiology trial. trees were thinned to a range of crops and although fruit size was negatively related to crop load, there seemed to be a threshold beyond which further thinning was not effective.

Illinois (Mosbah Kushad): In the 2009 peach rootstock trial, controller 7 and 8 had low yields. In the 2010 rootstock trial with 'HoneyCrisp' G.935 and G.4814 had wind breakage. There were also high levels of cork spot on the fruit.

Indiana (Peter Hirst): Trees in the 2014 'HoneyCrisp' trial have grown moderately. they are studying the effect of bourse shoot length on flowering and working with tree scanning in an attempt to estimate tree canopy volume.

Iowa (Dianne Cochran): The 2010 organic apple trial was planted late due to wet soils during the spring and trees grew poorly. In the 2010 'HoneyCrisp' Rootstock trial, trees on 'G.11' and 'CG.3001' yielded the most. Generally, the Bud rootstocks produced the largest fruit. 'B.64-194' and 'B.67-5-32' rootstocks had low yields, but produced the biggest fruit. 'Supp.3' rootstocks had low yields but high zonal chlorosis. Overall yields were up compared to 2014.

Kentucky (Dwight Wolf): Data were sent for 'Redhaven' and 'Cresthaven' for the peach physiology trial.

Maryland (Chris Walsh and Mike Newell): 'Fuji' and 'Gala' trees survived well on Geneva rootstocks under local conditions, but 'Cripps Pink' has not performed well on G41 and G935 due to wind damage. The apparent incompatibility and/or rootstock brittleness in these elite rootstocks is of concern. Dutch stubs in Brookfield Gala were particularly susceptible to the severe fire blight infection during the shoot blight epidemic in 2015. Many of the renewal shoots led to trunk damage.

A number of old research orchards planted at Keedysville were removed during the past few years. These sites were chisel plowed to remove old roots and bio-

renovated with two crops of rape and seeded to tall fescue prior to replanting in 2015. Trees for these plantings have Fuji budded on G935, G41, G202, G214, G11, G222, Bud 9, M9 (Nic29), M9 (Nakb337) and G42, planted at 6'x12' and 3'x12' spacings on a four wire 9' trellis system. They were propagated in a commercial nursery and planted in spring, 2015.

In the Peach physiology study yields were lower in 2014 and 2015 due to unfavorable spring weather. Consequently the fruit size range was not as great as expected.

Massachusetts (Wes Autio and Jon Clements): In the 2009 NC-140 Peach trial, largest trees were on Guardian and smallest trees were on Controller 5. Yield was similar, but yield efficiency was greatest for trees on *Prunus americana*. In the 2010 NC-140 Apple trial, largest trees were on B.70-20-20; smallest trees were on B.71-7-22. Greatest cumulative yields were harvested from trees on CG.3001 and lowest yields from trees on B.71-7-22. The most yield efficient trees were on G.41N. The largest fruit were harvested from trees on B.7-3-150. In the 2014 NC-140 Apple trial, largest trees were on V.6; smallest were on G.11. Yield was greatest from trees on G.30 and least from trees on G.202. The most yield efficient trees were on G.30. In the 2015 NC-140 Organic Apple trial, trees on G.890 were the largest; trees on G.16 were the smallest.

Michigan (Greg Lang):

2010 Sweet Cherry Training Systems x Rootstocks Trial (*coordinator and cooperator*): After 6 years, the KGB canopy architectures are most vigorous as determined by trunk cross-sectional area (TCSA) across rootstocks, followed by TSA and UFO (similar), and the twice-as densely planted SSA trees are least vigorous. When vigor is compared based on summer pruning of excessive top (leader) growth, KGB is most vigorous, followed by TSA, with the fruiting wall canopies of the UFO and SSA least vigorous. Trees grown under the retractable roof structure (Cravo) are more vigorous than trees grown under the pole-and-cable plastic row covers (Voen). Yields continued to fall short of expected potential due to poor 2015 pollination conditions, being relatively comparable to 2014 after extensive June drop. Yields were affected more under the retractable roof due to earlier bloom when climatic conditions were cold and cloudy, minimizing pollinator activity. It is suspected that TSA yields in under the retractable roof were also differentially affected by raccoon predation, the central leaders being easier to access than the fruiting wall (UFO and SSA) or bushy upright fruiting unit (KGB) architectures. Across protection systems, 'Benton' yields (on a per orchard area basis estimated spacing adjusted for tree vigor) were highest (5.9 ton/acre) for TSA and UFO trees on Gi3, followed by TSA/Gi5 and KGB/Gi3 trees. Yields on SSA trees continued to decline from their peak in 2013. Cumulative orchard yields (2013-2015, projected with adjusted tree spacing) have been highest for TSA/Gi3 (16.3 ton/acre), followed by UFO/Gi3 (13.7 ton/acre), SSA/Gi3 (9.4 ton/acre),

UFO/Gi5 (8.7 ton/acre), and TSA/Gi5 (8.5 ton/acre). A preliminary renewal pruning trial to compare the currently-recommended selective removal of the 1-2 largest fruiting units in highly-productive dwarfing UFO 'Rainier'/Gi3 trees with whole-tree renewal of all fruiting units showed promise for the latter. The trial will be expanded to the coordinated trials in 2016.

2010 and 2011 Tart Cherry Training Systems x Rootstocks Trials (independent trials):

Grown in a high density, hedgerow-type canopy for over-the-row mechanical harvest, 'Montmorency' on its own roots has been very unproductive through the first 6 years in the orchard. Productivity on Mahaleb rootstock has been moderate, on Gisela (3, 5, and 6) very good. Several new MSU rootstocks have promoted very high precocity and productivity through 5 years, in some cases at the expense of adequate vegetative growth for filling allotted space. Fruiting wood renewal pruning trials are underway; a preliminary trial of "whole-tree renewal" for UFO-style multi-leader trees looked more promising than selective renewal of the largest 1-2 fruiting leaders.

2010 'Honeycrisp' Apple Rootstock Evaluation Trial: In 2015, the highest yield efficiency with 'Honeycrisp' was on B.10, M.9Pajam and M.9T337, all with comparable fruit size. Cumulative yield efficiency for 2013-2015 has been highest on G.935, G.11, and B.9, though fruit size has tended to be smaller on G.935 than on the other two highly efficient rootstocks. 2015 was a bad year for incidence of 'Honeycrisp' bitter pit, with on-tree bitter pit exceeding 50% for trees on Supp.3 and PiAu.51-11; incidence in 2013 was also relatively high on Supp.3. Leaf nutrient analysis in 2014 revealed trees on Supp.3 had among the lowest levels of Ca and Mg, and highest levels of B. However, leaves of trees on PiAu.9-90 had similar nutrient levels, but minimal bitter pit. Plans are underway to examine rootstock effects on bitter pit and fruit nutrient levels in more detail in 2016.

2014 'Honeycrisp' Apple Rootstock Evaluation Trial : The Vineland rootstock series, V.1, V.5, V.6, and V.7 are more vigorous thus far than any other rootstock except G.30. Yields in 2015 (Year 2) were highest on V.5 and lowest on G.202 (which also had the smallest fruit), but yield efficiency was highest on G.969. Bitter pit was highest most prevalent on G.41 and G.935.

2015 'Modi' Apple Organic Rootstock Evaluation Trial: Trees on G.890 were nearly twice as vigorous (based on seasonal change in trunk cross-sectional area) as on any of the other rootstocks during this establishment year. The least vigorous trees were on G.214.

Objective 2: A cherry rootstock selection program (based on sour cherry scion breeding efforts) at MSU 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.

New Mexico (Shengrui Yao, Robert Heyduck and Steve Guldán): New Mexico just planted its first NC140 trial-2015 organic apple rootstock trial.

Minnesota (Emily Hoover): The 2010 Honeycrisp planting produced adequate fruit this year even though the mid-winter low temperature was -30C. There was no tree death on any rootstock in planting. The 2014 Honeycrisp planting, tree growth was adequate. There was some sub-lethal Roundup damage with leaves cupping and growth slower than would be expected given the ideal growing conditions. Minimum winter temperatures in MN of -27C occurred in January 2015.

Members of the group continue to work on making research-based information available to anyone who would like to use it through eXtension (<http://www.extension.org/apples>). This project was funded through August 2014 with USDA SCRI funding. We link to the primary website for the research group, www.nc140.org. This site continues to be one of our primary outreach components serving as an important outreach tool. We should discuss the continuation of this site and its role within the research/extension effort.

New York (Jaume Lordan Sanahuja, Poliana Francesca, and Gennaro Fazio, Terence Tobinson was absent): In the 2010 'HoneyCrisp'/'Fuji' trial The most dwarfing stock in this trial was B.71722, which was too dwarfing for commercial use. Biennial bearing is an issue in this trial. Biennial bearing index was calculated for 2013 - 2014 and the next two cropping years (2014 - 2015). Rootstocks with low biennial bearing index included CG.4003, G.41TC, CG.4814, B.10, Piau51- 11 and G.202N. In the 2014 'HoneyCrisp' rootstock trial higher yields were harvested with G.5890, V.7 and G.30. On the other hand, G.935 and G.202 had the poorest yields. In the 2009 pear rootstock trial there have only been a few trees lost to fire blight (one each on OHF87, and Pyrodwarf ; and two on OHF97). With Concorde, higher number of fruits was observed with Pyrodwarf, but these fruits were significantly smaller than OHF87 and OHF97, which did not give a significant higher yield. With Taylors Gold OHF87 and OHF97 had the greatest yield and Pyrodwarf had low yield OHF97 had large fruit size compared to Pyrodwarf. In the 2005 pear rootstock trial 708-36, Pyro-2-33 and Fox -11 are superior rootstocks and should be considered for commercial trials. However the high tree mortality of Fox-11 is of concern.708-36 is dwarfing and can be planted at high density in the Tall Spindle or Super spindle system (1,200 -2,500 trees/acre). It may be too dwarfing for Bartlett but with Bosc it may have the proper vigor. Fox-11 and Pyro 2-33 are intermediate in vigor but less than OHF87 and OHF97 the current industry standards. Pyro 2-33 and Fox-11 should be planted in the Tall Spindle system at ~1,000 - 1,200 trees/acre. Our previous trials with Pyro 2-33 were also very positive which gives us more confidence to recommend this stock for commercial planting.

In the 2010 cherry systems/rootstock trial the highest cumulative yield per acre (or ha) was observed in super spindle with Gi.3 and tall spindle with Gi.5 and Gi.6, having the highest yield efficiency. In the 2009 peach rootstock trial Survival was

poorest with Fortuna, and Imperial, followed by BH5, KV010127 and Krymsk 1 which all had reduced survival. Americana, Guardian, KV-23 and Empyream2 also had survival rates below 90%. Some trees of P. americana, Empyream2, Imperial Fortuna, KV-23, KV-27 and HBOK 32 which did not grow from the scion after planting had the rootstock alive indicating those trees were damaged in the nursery. The most productive stocks over the first 7 years were Atlas, Kryms 86, Guardian, Lovell, HBOK32, BH-5, KV-27, HBOK10, Mirobac, Empyream2, KV-23, Viking, Imperial, Americana, Krymsk1 and lastly Fortuna and Controller5.

In 2014 the Geneva apple rootstock program released one new rootstock, G814. This rootstock has been tested as CG4814. It is semi-dwarfing (about M.26 size). 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.

North Carolina (Mike Parker): the 2009 peach rootstock trial is at the Sandhills station and the 2010 'Fuji' rootstock trial is at Fletcher. G.4004 had the highest yield in 2015.

Nova Scotia (Suzanne Blatt): 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. Rootstocks in the 2010 Apple Rootstock ('Honeycrisp') trial appear to be influenced by warmer night temperatures in Nova Scotia. Harvest readiness as determined by the DA meter is strongly affected by large changes in daily temperature. Projects in various stages of data collection and evaluation include the following: 2010 Apple Rootstock ('Honeycrisp'), 2010 Sweet Cherry Rootstock and Training Systems, 2015 Organic Apple Rootstock. The 2003 Pyrodwarf Pear Rootstock trial finished this year and the 2015 Organic Apple Rootstock trial has been initiated.

Ohio (Diane Miller): The 2010 *Honeycrisp rootstock trial* is located at Bachman's Sunny Hill Fruit Farm in Carroll, OH (south of Columbus). Researcher Diane Miller and grower Gregg Bachman collaborate on maintenance of the trial and data collection. B.9 rootstock has performed exceptionally poorly in this trial as these trees are small and weak. G.935 and M.26EMLA have produced the optimal tree size for this tall spindle system. However, four of 10 G.935 trees have died; 3 in the first year. Survival of M.26EMLA is 100%. This planting was over-cropped in 2014 and responded with very light bloom and very light yields in 2015.

Ontario (John Cline):

2013 Vineland Apple Rootstock Experiment:

Ten trees each of Honeycrisp on seven different rootstocks (V.5, V.6, V.7, M.7, M.9 T337, M.26 and MM.106) were planted in 2013 at the University of Guelph, Simcoe Horticultural Experiment Station, at a spacing of 1.3m within and 4.0 m between rows (1923 trees/ha-1; 779 trees/acre-1). Trees are planted using a vertical axe type training

system and are trickle irrigated. Trees will be monitored annually for trunk circumference growth, tree height and spread, yield, fruit size, rootstock suckering and longevity.

2014 Vineland/Cornell Apple Rootstock Experiment:

Ten trees each of Honeycrisp and Aztec Fuji on 17 different rootstock (B.10, G.11, G.202, G.214, G.30, G.41, G.5890, G.935, G.969, M.26 EMLA, M.7, MM.106, M.9 T337, V.5, V.6, V.7) are planned for 2014 at the University of Guelph, Simcoe Horticultural Experiment Station. Planting details and data collection protocols are being established at the 2013 annual meeting in Boise, Idaho. Trees will be planted using a spindle type training system and will trickle irrigated. Trees will be monitored annually for trunk circumference growth, tree height and spread, yield, fruit size, rootstock suckering and longevity.

2010 Peach Spacing Experiment:

'Coralstar' and 'Allstar' peach trees on 'Bailey' rootstock are planted in 30 m plots with trees within each plots spaced 1.0, 1.25, and 1.50 m within the row and 4.0 meters between rows. Treatments are replicated 4 times. Tree density ranges from 1667 –2500 trees/ha at these spacing. Trees are planted using a 'Fusetto' central leader type spindle system with wire trellis and are trickle irrigated. Trees will be monitored annually for trunk circumference growth, yield, fruit size, suckering and longevity.

2012 Rootstock Experiment:

Twelve trees each of 'Stacatto' and 'Sentennial' on three different rootstock –Krymsk 5 (*P. fruticosax P. lannesiana*), Krymsk 7 (*P. lannesiana*), and Weiroot 13 were planted in 2012 at the University of Guelph, Simcoe Horticultural Experiment Station, at a spacing of 2.5 m within and 4.0 m between rows (1000 trees.ha-1). Trees are planted using a Vogel (wire trellis and supported) training system and are trickle irrigated. Trees will be monitored annually for trunk circumference growth, tree height and spread, yield, fruit size, rootstock suckering and longevity. In 2014, significant shoot dieback was experience in the spring caused by the severe winter temperatures. Very few flowers were found to survive and set a viable crop.

Tart Cherry Rootstocks

2012 Montmorency Rootstock Experiment

Eight trees each of Montmorency on 5 different rootstocks (Mahaleb, Gisela 6, Krymsk 6, Krymsk 7 and Weiroot 13) were planted in 2012 at the University of Guelph, Horticultural Experiment Station, Simcoe at spacings of 1.5, 2.0, 3.0, and 4.0 m within row and 4.5 m between rows, Tree density ranges form 556-1481 trees/ha; 225 –600 trees/acre. Trees are not supported (free standing) and are trickle irrigated. Trees will be monitored annually for trunk circumference growth, tree height and spread, yield, fruit size, rootstock suckering and longevity.

2013 Montmorency Rootstock Experiment.

Five 3-tree plots of Montmorency on 5 different rootstocks (Mahaleb, Weiroot 13, Weiroot 158, Weiroot 10, and Weiroot 72) were planted in 2013 at the University of Guelph, Horticultural Experiment Station, Simcoe at a spacing of 1.35m within row and 4.5 m between rows 1646 trees.ha⁻¹; 666 trees.acre⁻¹), Trees are not supported (free standing) and are trickle irrigated. Previous research has indicated the approximate size of the Weiroot clones as (% of standard seedling): Weiroot 13(76%), Weiroot 158(51%), Weiroot 10(87%), and Weiroot 72(35%). Trees will be monitored annually for trunk circumference growth, tree height and spread, yield, fruit size, rootstock suckering and mortality.

Oregon (Todd Eighorn): No written report. Oregon has the 2009 pear Rootstock Trial and the 2013 pear Rootstock x Systems Trial: The Bi-axe system seems to control vigor. They are also evaluating Amelanchier as a potential rootstock. At this point some of the clones appear to be very dwarfing with short shoots and high spur density. There is also some work with training systems and quince rootstocks.

Utah (Brent Black): break strength of specific apple scion-rootstock combinations, with specific interest in G.41. Graduate student Stuart Adams is evaluating graft types and PGR treatments on both graft union strength and function (hydraulic properties). Stuart is currently analyzing 2015 samples and will be writing up results in early 2016 for publication.

2009 Redhaven Peach Rootstock Trial (Kaysville Planting). Trees on Viking are most vigorous, followed by Br. Hybrid 5, and least vigorous on Krymsk 1. Yield in 2015 was highest on KV010-123, followed by Br. Hybrid 5, and lowest on Krymsk 1. Trees on Mirobac had the most root suckers per tree, followed by I. California, and ten rootstocks had less than one root sucker per tree. One tree of I. California died in 2015. There continues to be an unexplained lack of vigor in the row containing rep 8 of all the rootstocks.

2009 Redhaven Peach Rootstock Trial (South Shore Farm Planting). Trees on Br. Hybrid 5 are most vigorous, followed by Atlas; and least vigorous on Controller 5. Yield in 2015 was highest on B. Hybrid 5, followed by Mirobac, and lowest on Controller 5. Trees on *P. americana* have the most rootsuckers per tree, followed by Penta and Krymsk 1, and ten rootstocks had no root suckers. This location has a more alkaline soil and Lovell is much smaller (and more chlorotic) compared to the other rootstocks (compare tables 1 and 2). Iron chelate has been withheld from this block, but the plot does receive sulfur-treated irrigation water. One tree of KV010-127 died in 2015.

2009 Peach Crop Physiology Trial. Due to insufficient fruit set in prior years, the trees in this trial have been removed.

2010 Aztec Fuji Apple Rootstock Trial (Kaysville Planting) (Table 3). Trees on PiAu9-90 are most vigorous, followed by B.70-20-20; and least vigorous on B.7-20-21. Yield in 2015 was highest on B.64-194, followed by G.5202, and lowest on B.7-20-21. Trees on G.935TC averaged 20.8 root suckers per tree, trees on 14 rootstocks averaged less than three root suckers per tree. One tree of M.26EMLA died in 2015. The most vigorous trees have way over-grown their allotted space, likely due to poor or no fruit set in the early fruiting seasons.

2010 Honeycrisp Apple Rootstock Trial (Santaquin Planting). Inadequate support in the first few years of this planting resulted in graft union breaks and tipped over trees. Some trees also over-cropped, including in 2014. Due to a combination of these factors, a number of rootstocks have not adequately filled their space. A combination of biennial bearing and late spring frost resulted in no fruit set in 2015. We have ceased collecting data at this off-station location.

2010 High Density Tart Cherry planting. Planted in April 2010 with 4 rootstocks (Gisela3, 5, 6 and Mahaleb), 3 training systems (1, 2 and 4 leaders), and 4 tree spacings (4, 6, 8 and 10') in an incomplete factorial. Trees were pruned/thinned of fruiting wood in March 2015 due to a moderate to heavy level of fruit buds on the trees, and height was reduced as needed to accommodate the overhead mechanical harvester. Mechanical harvest was carried out in 2015 after making some additional modifications to the harvester.

2014 Fuji Apple Rootstock Trial. (Table 4) Trees on V.5 are most vigorous, followed by V.6, and least vigorous on B.10. Trees on all rootstocks yielded some fruit in 2015; with trees on G.11 cropping the most fruit/tree; followed by M.9T337; and fewest fruit/tree on B.10. Trees on all rootstocks had one or fewer rootsuckers per tree. No trees died in 2015.

A non-profit foundation (Improving Perennial 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.

South Carolina (Greg Reighard): In the 2009 Peach Rootstock trial there were significant differences in tree size, survival, yields and yield efficiency among rootstocks (see addendum). Peach seedling rootstock cultivars were the most productive and yield efficient when compared to the *Prunus* hybrid rootstocks. Many plum species and hybrids such as Penta, Tetra, Imperial California, Fortuna, and Krymsk®1 have had poor survival and/or yields and do not look promising as peach rootstocks even for high density systems.

For the Peach Physiology crop load trial both Redhaven and Cresthaven (Crimson Lady frozen out) yields again correlated with crop load densities but fruit size was

smaller than previous years possibly related to a warm flowering period before thinning occurred.

In the 2014 Apple Rootstock trial most trees reached the top wire and cropping was good. Yields ranged from 13.3 and 12.4 kg/tree on V.5 and V.6, respectively to a low of 3.6 kg/tree on M.26. Red skin blush only reached 25% and was not commercially acceptable. Brix were ~15. Trees on V.1, V.5, V.6, V.7, G.30 and G.969 were more vigorous than on M.26.

Rootpac 20 (Densipac) and Rootpac 40 (Nanopac) from the Spanish Company Agromillora Iberica were obtained for the planned 2017 Peach Systems Trial.

Prunus rootstocks that had *P. dulcis* or *P. domestica* in their lineage have had poor survival, but no rootstocks of 100% *P. persica* have died.

Virginia (Greg Peck and Kieth Yoder): In addition to the 2014 Apple rootstock trial, there is a sweet cherry planting with multiple comparisons among three rootstocks, twelve cultivars, three training systems (vertical axe, UFO, and KGB) under the Voent Orchard Covering System. A high-density 'Daybreak Fuji'/'M.9' apple planting systems trial was established with replicated blocks of trees spaced in 0.31 m (1') increments between 0.61 m (2') and 1.83 m (6'). The trees spaced 1.83 m are trained in a vertical axe form. The others are trained in a tall spindle. Fertilizer input type by apple rootstock genotypes (M.9, B.9, G.935, G.214, and G.41) container study (Ph.D. project of Ashley Thompson).

Yoder is evaluating TmRSV susceptibility in a test planting: In cooperation with Terence Robinson and Gennaro Fazio, 39 new Geneva rootstock selections and older standards were planted at site at Winchester AREC with history of endemic Tomato Ringspot Virus (TmRSV) problems, dagger nematodes, and broad-leaf weeds. All rootstocks had been grafted to Super Chief Delicious scion and grown by Waffler Nursery. Test rootstocks include: industry standards: M.9/337, M.26, M.7, MM.106, and Bud.9; earlier Geneva releases: G.11, G.30, G.41, and G.65; more recent releases: G.202, G.210, G.214, G.222, G.935, G.969, and G.890; and experimental rootstocks: G3001, G3010, G3902, G4002, G4010, G4011, G4013, G4088, G4105, G4213, G4218, G4288, G4292, G4809, G4814, G5008, G5030, G5087, G5257, G5890, G6210, G6874, and G6969. Trees were planted in 10 randomized blocks (five rows with two replications per row).

The planting is drip-irrigated and surrounded by four-strand polycord electric fence to minimize deer browsing. On 5 Oct, six of the ten replications were challenge-inoculated by chip-grafting a virus infected root bark patch into the rootstock above the soil line and below the graft union. Four replications were left for natural infection. Rootstock bark samples that were removed during the chip-budding inoculation were frozen for future virus testing. Populations of the Dagger nematode vector (*Xiphinema americanum*) in composite replicate samples taken 13 Oct had a mean of 48/100 cc of soil, indicating potential for natural infection in this broad-leaf weed infested area. Tree graft unions will be examined semi-annually for symptoms (expected in the susceptible MM.106 rootstock within 2 to 5 years after inoculation). We mapped 13 trees that had

reddish-purplish foliage in late season, indicating possible onset of symptoms prior to inoculation. (MM.106 appeared normal).

Washington (Stefano Musacchi): The 2014 apple rootstock trial was established according to the protocol. An apple training system and rootstock trial was established in 2013. Two thousand trees of the new WSU scion variety WA 38 (Cosmic Crisp™) propagated on M9-Nic 29 and G41 rootstocks were planted in June 2013 in two locations at the WSU Sunrise (Wenatchee) and WSU Roza (Prosser) orchard to compare vegetative and productive performance. In both sites, two main training systems are compared: spindle (3 ft x 10 ft) and V-system (1.5 ft x 10 ft). Another trial with WA 38 bi-axis trees (1 year younger) on the same rootstocks has been set up to assess the possibility to mechanize thinning, pruning and harvest. Both orchards are irrigated with sprinkles and drippers and a weather station including soil moisture probes was also installed. Soil texture analyses revealed that WSU Sunrise orchard tends to be sandier than the WSU Roza site, which has a higher percentage in clay and silt. The first fruit yield was harvested only in Roza, while in 2015 both the experimental orchards had a significant crop.

For objective 2: A new breeding program was initiated in June 2015 at WSU with a focus on producing dwarfing precocious rootstocks for pear (Evans/Dhingra).

For Objective 3, potential new *Pyrus* seedling rootstocks are being propagated through tissue culture to enable small scale testing of dwarfing capability (Dhingra/Evans). Several potential new *Pyrus* rootstocks were imported from the Musacchi program in Italy to the CPCNW. Once through quarantine and virus testing, these will be propagated for trial. (Evans/Musacchi)

For Objective 4, 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). These plants were grown in the greenhouse for the summer of 2015 in pots and will be used for experiments related to effect of abiotic stress on the uptake of calcium and nitrogen. This experiment will combine isotope tracers, whole plant mass balance uptake and distribution models with metabolomics and genomic profiling.

Wisconsin (Matt Stasiak). For the 2010 Apple Rootstock Trial a number of rootstocks continue to maintain high cumulative yield efficiency compared to the widely available commercial rootstocks B.9, M.9T337, M.26EMLA. These include the Geneva and Cornell Geneva advanced rootstock selections G41N, G41TC, G935TC, G935N, G11, CG2034, CG3001, CG4003, CG4214, and CG5222. Other high yield efficiency rootstocks include B.10, Supporter3 and M.9Pajam2. Since establishment, this planting has experienced a number of extreme cold weather events that have influence growth and fruiting. These include snowless ground conditions in January and February of 2013 with soil temperatures below -5°C, resulting in root injury of various rootstock; three winter temperatures events in 2014 of -30°C with high solar flux, causing southwest injury; and -20°C in early November 2014, prior to leaf drop, possibly resulting in damage leading to fruit set and development anomalies. For example, average fruit

In the 2014 Apple Rootstock the smallest trees, in order of increasing trunk circumference, were G.202, M.9T337, B.10 and G.11. The largest trees, in order of increasing trunk circumference, were V1, V7, V6, G5890, V5, and G30. Second year per tree yields were highest on G.5890 and G.30 and lowest on G.202. When estimated per acre yields were calculated (a number of rootstocks yielded near Wisconsin state averages for bearing acreage, which is amazing, considering that this was on two year old trees.

For the 2015 Organic Apple Rootstock all trees planted survived and grew well as soil moisture conditions were almost ideal due to frequent rainfall events and the application of woven poly mulch. The majority of trees, although many were whips at planting, grew to the top wire that was placed at a height of 2.9 meters. Trunk cross sectional area measurements increased by a factor of greater than 2 times for all rootstock treatments.

Subcommittee Meeting Reports

Project rewrite committee (Mike Parker, chair): The committee met the first evening and decided to reduce the number of objects from 5 to 4, by eliminating Objective 3. Gennaro Fazio will take the lead on objective 2. There was little discussion before Wes Autio moved to accept the suggested Objectives. The motion was seconded by Emily Hoover and passed.

Emily Hoover suggested that we need to enhance the NC-140 website. Carlos Crisosto said he may be able to host the site and Rob Crassweller said he would check with the IT people at Penn State.

Emily Hoover proposed some of the \$15,000 award money to develop a small executive committee to continue working on NC-140 issues during the year and decide how to spend the funds. Those nominated to serve on the committee included John Clemens, Emily Hoover, Todd Einhorn, Wes Autio, and we still need one more person.

Essie Fallahi motioned that the secretary draft a letter to the supervisors of Rachel Elkins and Ted DeJong to describe the successful meeting that was planned and executed. Mike Parker seconded the motion and the motion passed.

Tours

During the afternoon of November 3, the group visited the Wolfskill Experimental orchards in Winters. John Preece gave an overview of the USDA Grape National clonal germplasm Repository and Chuck Leslie discussed the walnut germplasm collection. Ted DeJong and Katherine Pope gave an overview of the Prune rootstock trial and the prune breeding program and Ted also described the peach rootstock trial, the pistachio and olive plantings and the almond and cling peach breeding program. A neighboring fruit grower explained his involvement with dried fruit and walnut production. There was a group dinner at the Buckhorn Restaurant.

On November 4, there was a full day of tours. The group visited Luther Barbank's home and gardens in Santa Rosa. Lunch at the world Famous hamburger Ranch & Bar-B-Que in Cloverdale was sponsored by the California pear Advisory board. In Mendocino County, the group saw the 2013 NC-140 Pear Systems Trial in Hopland. The group also toured the 2005 NC-140 Bartlett and Bosc Trials in Talmage and visited with a pear grower to discuss the processing pear industry. The group stopped at Cache Creek vineyards & Winery in Clear Oaks in Lake County for a wine tasting and dinner sponsored by the California Cherry Commission. On Thursday, November 5, there was an optional field tour to the northern Central Valley. The tour included apples, olives, pears, cherries, walnuts in "San Joaquin county and Sacramento/San Joaquin Delta. The group then visited Sierra Gold Nurseries in Yuba County to view micro-propagation facilities and outdoor growing grounds.

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