**State: Idaho**

University of Idaho, Pomology Program, In Cooperation with Cornell University

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1. **Impact Nugget:** Several Geneva and other apple rootstocks, including Geneva 935, Geneva 4004, and Geneva 41seem to be suitable for climate and soil conditions of southwest Idaho.
2. **New Facilities and Equipment:** Sophisticated and modern regular atmosphere cold storage facilities were completed at the University of Idaho Parma Research and Extension Center for our apple project, including several NC-140 projects in 2017. We know have five large rooms to conduct research on postharvest physiology of various fruits.
3. **Unique Project Related Findings:** ‘Fuji’ apple yield efficiency, fruit quality attributes, and leaf minerals varied significantly among rootstocks. Rootstocks had a major effect on tolerance to the cold that occurred during the freezing front that on November 2016-17, while trees were no acclimated yet.

1. **Accomplishments Related to each of the 5 objectives:**

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

***Results for the 2010 apple rootstock trial at harves:***

1. ‘Aztec Fuji’ on CG.4004, CG.3001, G.41N, CG.5222, and B.64.194 were among the highest yielding trees while those on CG.4003, B.71722, and B.702021 had the lowest yield per tree in 2016 (Table 1).
2. Trees on G.41TC, G.41N, and CG.5087 had the largest but those on CG.2034, CG.4003, and B.702021 had the smallest fruit among all trees (Table 1). Lower yield of CG.4003 and B.702021 did not lead to a larger fruit size, which could be suggest that these rootstocks are not suitable for conditions of the Intermountain West region.
3. B.9, which is a commonly used rootstock in the Pacific Northwest apple industry, tended to have both low yield and small fruit size.
4. Fruit from trees on B.702021 and CG.4003 had the highest soluble solids concentration (SSC), firmness, and best skin color, mainly because canopies and fruit sizes of these trees were smallest and fruit were exposed to light.
5. Fruit from trees on CG.2034 had more green color and least SSC and those on CG.3001 and B.702020 had the lowest firmness at harvest.
6. Fruit from trees on CG.2034 had more advanced starch hydrolysis (more starch degradation pattern, SDP) while those on CG.4003 and CG.5087 had the lowest SDP.
7. ‘Aztec Fuji’ on B.73150 and Supporter 3 had higher but those on CG.2034, CG.5087, and G.41TC had the least fruit russet at harvest (Table 2).
8. Trees on G.41TC and CG.4214 had the highest percentage of water core while those on G.41N and CG.2034 showed no water core at harvest.
9. Trees on CG.5087, M26EMLA, G.41N, and M.9Pajam2 had higher but those on CG.4003 and CG.4214 had the lowest levels of leaf N.
10. In many cases, leaf Ca had inverse relationship with leaf Mg. For example, Trees on CG.4214, CG.2034, and CG.5087 had higher leaf Ca but lower leaf Mg during 2016. However, there were trees, such as those on CG.4004 that both higher leaf Ca and Mg in 2016.
11. Leaf K seemed to have a positive relationship with yield in some rootstocks such as CG.4004 and negative one in others such as B.702021. Potassium is an important element that can change depending on the sources-sink partitioning and many other physiological processes. Thus, fruit analysis, in addition to leaf analysis is essential to have a more clear interpretation for K partitioning.
12. Concentrations of leaf Zn and Fe were higher in the trees on B.702021 rootstock, perhaps partially due to the lower yield or lower percent dry weight in these trees.

***Results of 2014 apple rootstock trial at harvest:***

Two experimental orchards of ‘Aztec Fuji’ and ‘Honey crisp’ apple on various rootstocks were established at the University of Idaho, Parma Research and Extension center on March 3, 2014. Trees were planted and trained according to the protocol.

1. ‘Aztec Fuji’ trees for the new 2014 planting were not in optimum conditions when received. Feathers were either dead or broken with severe die back. Trees started to leaf out two week late and did not start to grow until mid-summer. These leaves were small and resembled severe zinc deficiency. Trees were fertigated by high rates of zinc and urea to keep them alive. Tree growth improved by the end of growing season. Trees on V.5 and V.6 were more vigorous than those on many other rootstocks during 2014 growing season. We had a severe and sudden freeze on November 17 and 18, 2014. During those nights, temperatures plunged down from 55-65o F daytime to -5 o F at night and caused severe damage on numerous trees and nursery stocks in the region. We observed severe damages on most trees on ‘’V” series rootstocks. Some of these damaged trees grew during June and July 2015, but finally collapsed during August and September 2015. In March 2016, branches that grew from a lower part of the damaged tree (but above the bud union) were trained into a tall spindle system. These trees had excellent growth during 2017 and are recovering. Trees on rootstocks other than V series such as Geneva series seemed to be slightly better than others. We are taking yield and growth measurements and assessing the extent of this cold damage. Leaf samples were taken for mineral analysis and fruit samples were taken in early October 2016 and 2017 and analyzed for quality attributes at harvest and after storage.
2. Severe incidences of bitter pit and fruit cracking were observed in ‘Honey Crisp’ apples and the severity varied based on rootstocks.

***Results of 2010 Apple tree architecture and rootstock study:***

This experiment started in 2010 with two orchard designs (Tall Spindle and Central leader with 4 leaders), each on two rootstocks (Bud9 and Nic9). Tree spacing at 3 ft seemed to be sufficient for trees on Bud9 but too tight for those on Nic9. A tall spindle with Bud9 rootstock is showing good results. 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 these trees were severely pruned in March 2017 and color was improved in 2017. Trees with both Nic9 and Bud9 had lower yield in 2016 as compared to 2015, but more crops in 2017.

***Results of 2015 Apple tree organic rootstock study:***

This experiment started in 2015 with several rootstocks. In this study, ‘Modi’ tree were plated at 5 x 13 ft, and trained according the protocol. Tree growth was satisfactory and trees on most dwarf rootstocks had a few fruits in 2016 and more yield in 2017. Fruit quality attributes, trunk cross sectional area, and leaf mineral concentrations were measured in 2016 and 2017. Codling moth infestation was very severe in fruit from all rootstocks in 2016 and 2017. Not other major report is available to report on this study.

***2015 Peach physiology:***

Three cultivars of peaches including Crimson Lady, Red Heaven, and Crest Heaven were used for 2016 crop load study. This experiment was terminated in 2017. There seemed to be a threshold beyond which further thinning was not effective. Complete data will be reported later.

Objective2. To develop improved rootstock for temperate-zone fruit trees using state-of-the-art genomic tools in breeding programs. N/A.

Objective3. To accelerate adoption of new rootstocks (a) by improving propagation techniques and (b) by acquiring new rootstocks from worldwide sources. N/A

Objective4. To better understand the impacts of biotic and abiotic stresses on scion/rootstock combinations in temperate- zone fruit trees.

1. Significant differences were found in the scion leaf minerals among rootstocks.

Objective5. To enhance the sustainability of temperate fruit farming through development and distribution of research-based information utilizing eXtension. N/A.

1. **Impact statements (if applicable):**

Growers of Idaho and the intermountain west region are following the performance of these rootstocks closely and will be using superior rootstocks in their plantings.

1. **Published written works:**

1. Autio, W., T. Robinson, B. Black, R. Crassweller, E. Fallahi, M. Parker, R. P. Quezada, and D. Wolfe. 2017. [Budagovsky, Geneva, Pillnitz, and Malling Apple Rootstocks Affect ‘Fuji’ Performance Over the First Five Years of the 2010 NC-140 Fuji Apple Rootstock Trial](https://user-23310503727.cld.bz/APS-Journal-July-2017/40" \t "_blank). Journal of the American Pomological Society. 72:167-182.

1. **Scientific and outreach oral presentations:**

The following groups received tours and educational classes, outreach, and presentations during the period of this project:

1. Apple growers of Idaho, Colorado, Utah, Oregon, and Washington received a comprehensive tour about performance of various rootstocks October 18, 2016.
2. Presented a talk entitled “NC-140 Progress Report from Idaho” at the annual convention of the NC-140 Conference, College Park, Penn State University, November 9-14, 2016
3. Presented a talk entitled “The Impact of Rootstock on Fruit Yield and Quality and Minerals” at the annual convention of the Idaho State Horticultural Society, November 17-18, 2016.
4. Presented an invited talk at the annual Conference of International Tree Fruit Association in Wenatchee in February 2017; approx. 450 people from worldwide.
5. On February 14, 2017, we had a daylong educational tour in Parma, Idaho and showed growers how to practice the new architectures and training in several rootstocks to commercial apple growers (35 growers participated).
6. We also had a daylong educational tour and lecture on February 25, 2017 and 43 Idaho apple growers participated and asked numerous questions and took notes. Also, each grower was asked to practice these new methods of training on different rootstocks.
7. Presented a tour and talked about the performance of various rootstocks to 45 apple growers during the general U of I Parma Field Day on June 18, 2017.
8. Potential apple growers who are currently row crop growers in Idaho.
9. Graduate students at Washington State University and University of Idaho.
10. Commercial stone fruit growers of Idaho, Washington, Utah, and Colorado.
11. **Fund leveraging,** specifically, collaborative grants between stations and members.
12. Received $ 7000 worth of chemicals from Wilbur Ellis Company for pest and disease control of rootstock projects.
13. Received approximately $ 8800 in labor and equipment (in-kind) from Idaho fruit industry for operation of various apple rootstock projects.
14. Our program has been a member of a team of NC140 scientists who secured considerable funding from SCRI. Our share has been about $160,000 over five years.

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| **Table 1. The effects of rootstocks on yield, fruit weight, color, sugar, firmness, and starch degradation pattern in ‘Aztec Fuji’ at harvest in 2016.** | | | | | | |
|  |  |  |  |  | Avg | Avg |
| Rootstock | Yield | Fruit wt | Color | Sugar | Firmness | Starch |
|  | (Kg/tree) | (g) | (1-5) | ( % ) | ( Kg ) | ( chart ) |
| B702020 | 76.28a-d | 278.95a-d | 4.20a-e | 13.48eg | 7.07i | 4.58b-f |
| B702021 | 0.90k | 86.81n | 4.69a | 17.04a | 10.09a | 5.02bc |
| B7068 | 63.95c-e | 236.39d-k | 4.29a-e | 14.17c-f | 7.64d-i | 4.97bcd |
| B71722 | 14.20jk | 196.67k-l | 4.00b-e | 14.73b-e | 7.90c-h | 5.2ab |
| B64194 | 81.45a-d | 246.35d-j | 3.63ef | 13.43eg | 7.32ghi | 5.24ab |
| B67532 | 71.42b-e | 259.90b-g | 3.63ef | 13.88c-f | 7.40ghi | 4.74b-e |
| B73150 | 57.07d-g | 246.68d-j | 4.35a-d | 14.50b-f | 7.66d-i | 4.58b-f |
| B9 | 47.94e-h | 205.12j-k | 3.92c-f | 14.20c-f | 7.70d-i | 4.97bcd |
| B10 | 61.77c-g | 227.48e-k | 3.88c-e | 13.88c-f | 7.65d-i | 4.98bcd |
| CG5087 | 65.44c-f | 299.80abc | 4.25a-e | 15.2bcd | 8.55bc | 3.83f |
| CG3001 | 95.38ab | 269.88a-f | 4.00b-e | 13.65e-g | 7.15hi | 4.69b-e |
| CG4003 | 14.99ijk | 149.05m | 4.66ab | 16.97a | 8.91b | 4.01ef |
| CG4814 | 55.76d-h | 230.72e-k | 4.31a-d | 14.70b-e | 8.23b-f | 4.83b-e |
| CG4214 | 37.70f-j | 250.56d-j | 4.29a-e | 15.37bc | 8.40bcd | 4.17def |
| CG4004 | 100.32a | 280.15a-d | 3.88c-e | 13.30eg | 7.45f-i | 5.10ab |
| CG5222 | 83.31a-d | 268.46a-f | 3.64ef | 13.60e-g | 7.33ghi | 4.83b-e |
| CG2034 | 42.59f-i | 151.89l-m | 2.25g | 12.20g | 8.25b-e | 5.92a |
| G11 | 57.47d-g | 243.98d-j | 3.69def | 13.89c-f | 7.47e-i | 5.06bc |
| G41N | 88.03abc | 305.54ab | 3.25f | 13.00fg | 7.32ghi | 4.83b-e |
| G41TC | 28.60h-k | 307.76a | 4.50abc | 15.80ab | 7.39ghi | 4.25c-f |
| G202N | 59.12d-g | 251.02d-i | 4.05a-e | 13.88c-f | 7.92c-h | 4.90bcd |
| G202TC | 43.78e-h | 215.87g-k | 3.83c-e | 14.33b-f | 7.91-ch | 5.04bc |
| G935N | 61.06c-g | 258.37c-g | 4.17a-e | 13.77df | 7.42ghi | 4.68b-e |
| G935TC | 45.56e-h | 212.24h-k | 4.21a-e | 14.77b-e | 7.84c-i | 4.89bcd |
| M9Pajam2 | 65.27c-f | 264.75a-f | 3.92c-e | 13.24eg | 7.30ghi | 5.18ab |
| M9T337 | 43.25fgh | 256.50c-h | 4.20a-e | 14.40b-f | 7.58e-i | 5.05bc |
| M26EMLA | 77.28a-d | 250.02d-j | 4.19a-e | 13.31e-g | 7.38ghi | 4.82b-e |
| PiAu5111 | 79.69a-d | 273.12a-e | 4.02b-e | 13.58eg | 7.22ghi | 5.13ab |
| PiAu990 | 34.80g-j | 208.35i-k | 4.00b-e | 14.00c-f | 7.86c-h | 5.14ab |
| Support3 | 35.31g-j | 224.77f-k | 4.17a-e | 14.40b-f | 7.95c-g | 4.99bcd |
| Mean separation within columns by LSD at 5% level. | | | | | | |

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| **Table 2. The effects of rootstocks on fruit disorders in ‘Aztec Fuji’ at harvest in 2016.** | | | | | | |
|  | %of | %of | %of | %of | %of | %of |
| Rootstock | Russet | Sunburn | Bitter pit | Crack | Green stain | Watercore |
| B702020 | 20.62abc | 30.94b-i | 1.09a | 1.00a | 0.00b | 51.67abc |
| B702021 | 19.01abc | 90.50a | 0.00a | 0.00a | 0.00b | 41.67a-d |
| B7068 | 15.83abc | 32.08b-i | 0.42a | 0.00a | 0.42ab | 23.61bcd |
| B71722 | 10.00abc | 60.19abc | 0.00a | 0.00a | 1.76a | 52.78abc |
| B64194 | 13.75abc | 20.63e-i | 3.75a | 0.00a | 0.00b | 25.00bcd |
| B67532 | 5.00bc | 18.33-f-i | 0.00a | 0.00a | 0.00b | 36.11a-d |
| B73150 | 29.58a | 49.58b-f | 1.67a | 0.00a | 0.83ab | 55.56abc |
| B9 | 16.25abc | 43.63b-f | 2.08a | 0.00a | 0.42ab | 20.83bcd |
| B10 | 13.33abc | 30.00-ci | 1.67a | 0.42a | 0.00b | 34.72a-d |
| CG5087 | 0.00c | 5.00hi | 0.00a | 0.00a | 0.00b | 0.00d |
| CG3001 | 5.00bc | 30.00c-i | 3.75a | 0.00a | 0.00b | 54.17abc |
| CG4003 | 4.29bc | 52.86b-e | 1.43a | 0.00a | 0.00b | 30.95bcd |
| CG4814 | 16.25abc | 25.00d-i | 0.00a | 0.00a | 0.00b | 2500bcd |
| CG4214 | 13.61abc | 44.17b-f | 0.83a | 0.00a | 0.00b | 69.44ab |
| CG4004 | 16.25abc | 6.25hi | 0.00a | 0.00a | 0.00b | 12.50cd |
| CG5222 | 18.33abc | 27.22d-i | 0.56a | 0.00a | 0.00b | 42.59a-d |
| CG2034 | 0.00c | 10.00gi | 0.00a | 0.00a | 0.00b | 0.00d |
| G11 | 13.33abc | 41.11b-g | 1.11a | 0.00a | 0.00b | 20.37bcd |
| G41N | 15.00abc | 0.00i | 0.00a | 0.00a | 0.00b | 0.00d |
| G41TC | 0.00c | 25.00d-i | 0.00a | 0.00a | 0.00b | 83.33a |
| G202N | 16.00abc | 42.00b-g | 4.00a | 0.00a | 0.00b | 33.33a-d |
| G202TC | 12.08abc | 34.17b-h | 0.42a | 0.42a | 0.00b | 22.22bcd |
| G935N | 16.43abc | 28.57c-i | 0.71a | 0.00a | 0.00b | 23.81bcd |
| G935TC | 19.17abc | 54.17bcd | 0.00a | 0.00a | 0.83ab | 33.34a-d |
| M9Pajam2 | 21.67abc | 36.11b-h | 3.33a | 0.00a | 0.00b | 22.22bcd |
| M9T337 | 10.00abc | 30.00c-i | 2.73a | 0.91a | 0.00b | 48.48a-d |
| M26EMLA | 20.83abc | 20.83e-i | 2.08a | 0.00a | 0.00b | 33.33a-d |
| PiAu5111 | 14.55abc | 25.00d-i | 0.46a | 0.45a | 0.91ab | 34.85a-d |
| PiAu990 | 15.00abc | 63.33ab | 0.00a | 0.00a | 0.00b | 16.67cd |
| Support3 | 25.83ab | 44.17b-f | 0.83a | 0.00a | 0.00b | 25.00bcd |

Mean separation within columns by LSD at 5% level.

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| **Table 3. The effects of rootstocks on leaf mineral concentrations in ‘Aztec Fuji’ in 2016.** | | | | | | | | | | | | | |
|  | N | Ca | | K | Mg | | Fe | Zn | | | Cu | Mn | |
| Rootstock | (% dwt) | (%dwt) | | (%dwt) | (%dwt) | | (ppm) | (ppm) | | | (ppm) | (ppm) | |
| B702020 | 2.47 b-e | 1.36 hi | | 1.56 a-e | 0.334 ab | | 76.56 b-i | 26.20 c-i | | | 8.11 bcd | 36.43 f-i | |
| B702021 | 2.57 abc | 1.31 i | | 1.64 ab | 0.270 b | | 90.35 a | 38.11 a | | | 8.79 ab | 29.09 h-k | |
| B7068 | 2.43a-f | 1.69c-g | | 1.40a-i | 0.52a | | 74.87c-i | 24.97f-i | | | 7.97bcd | 48.46bd | |
| B71722 | 2.52 a-e | 1.87 bcd | | 1.27 e-j | 0.294 b | | 86.56 ab | 31.67 bc | | | 10.02 a | 44.50 b-g | |
| B64194 | 2.54 b-d | 1.58 d-i | | 1.69 a | 0.293 b | | 72.15 d-i | 23.67 g-j | | | 8.06 bcd | 54.10 b | |
| B67532 | 2.46 a-e | 1.74 c-f | | 1.65 a | 0.323 ab | | 72.99 d-i | 26.14 c-i | | | 8.27 bcd | 38.89 c-h | |
| B73150 | 2.42 b-f | 1.74 c-f | | 1.42 c-h | 0.324 ab | | 80.71 a-e | 25.85 d-i | | | 7.18 d | 49.71 bc | |
| B9 | 2.44 b-f | 1.81 cde | | 1.21 g-i | 0.309 ab | | 88.69 a | 30.90 b-e | | | 8.52 bcd | 53.92 b | |
| B10 | 2.50 a-e | 1.93 abc | | 1.23 ij | 0.354 ab | | 84.05 abc | 26.95 c-i | | | 8.03 bcd | 54.05 b | |
| CG5087 | 2.66 a | 1.94 abc | | 1.34 c-j | 0.280 b | | 75.57 c-i | 28.25 c-h | | | 9.06 ab | 20.77 k | |
| CG3001 | 2.53 a-e | 1.91 bc | | 1.54 a-f | 0.330 ab | | 66.14 ij | 23.20 hij | | | 8.05 bcd | 30.15 h-k | |
| CG4003 | 2.21 fg | 1.53 e-i | | 1.11 j | 0.291 b | | 90.01 a | 35.54 ab | | | 7.76 bcd | 25.80 ijk | |
| CG4814 | 2.37 c-g | 1.65 c-h | | 1.26 f-i | 0.333 ab | | 76.86 b-g | 26.77 c-i | | | 7.66 bcd | 33.93 hij | |
| CG4214 | 2.14 g | 2.21 a | | 1.44 a-h | 0.268 b | | 75.07 c-i | 27.03 c-i | | | 7.67 bcd | 37.50 e-h | |
| CG4004 | 2.43 c-f | 1.91 bc | | 1.66 a | 0.398 ab | | 69.00 f-i | 23.79 g-j | | | 7.31 cd | 77.25 a | |
| CG5222 | 2.34 dg | 1.92 abc | | 1.65 a | 0.319 ab | | 66.36 hij | 25.14 f-j | | | 8.35 bcd | 29.40 h-k | |
| CG2034 | 2.36 cg | 2.17 ab | | 1.44 a-h | 0.225 b | | 82.48 a-d | 31.24 bcd | | | 8.68 abc | 25.12 jk | |
| G11 | 2.50 a-e | 1.78 c-f | | 1.20 hij | 0.379 ab | | 70.43 e-i | 26.82 c-i | | | 8.54 bcd | 47.04 b-f | |
| G41N | 2.61 ab | 1.60 e-i | | 1.30 d-i | 0.360 ab | | 67.52 f-j | 21.72 ij | | | 7.92 bcd | 41.77 c-g | |
| G41TC | 2.41 b-f | 1.56 e-i | | 1.63 ab | 0.249 b | | 59.35 j | 19.43 j | | | 7.62 bcd | 28.70 h-k | |
| G202N | 2.31 efg | 1.74 c-g | | 1.49 a-g | 0.322 ab | | 76.81 b-h | 26.92 c-i | | | 8.48 bcd | 38.2 d-h | |
| G202TC | 2.44 a-e | 1.68 c-g | | 1.35 b-j | 0.308 ab | | 76.20 b-i | 27.78 c-h | | | 8.18 bcd | 37.61 f-h | |
| G935N | 2.41 b-f | 1.81 cde | | 1.29 d-i | 0.303 ab | | 72.30 d-i | 28.47 c-h | | | 8.96 ab | 25.89 ijk | |
| G935TC | 2.35 c-e | 1.50 f-i | | 1.09 j | 0.358 ab | | 76.63 b-h | 29.39 c-g | | | 8.14 bcd | 28.47 h-k | |
| M9Pajam2 | 2.61 ab | 1.72 c-g | | 1.34 c-j | 0.334 ab | | 73.03 d-i | 28.06 c-h | | | 8.84 ab | 47.67 b-e | |
| M9T337 | 2.51 a-e | 1.72 c-g | | 1.24 g-i | 0.343 ab | | 77.99 b-f | 30.16 b-f | | | 8.61 a-d | 49.25 bcd | |
| M26EMLA | 2.61 ab | 1.69 c-g | | 1.50 a-g | 0.345 ab | | 76.06 c-i | 25.49 e-i | | | 8.12 bcd | 79.95 a | |
| PiAu5111 | 2.57 abc | 1.44 ghi | | 1.60 abc | 0.334 ab | | 74.52 c-i | 28.28 c-h | | | 8.18 bcd | 42.24 c-g | |
| PiAu990 | 2.40 bf | 1.34 i | | 1.47 a-h | 0.288 b | | 67.37 g-j | 26.25 c-i | | | 8.02 bcd | 35.64 g-j | |
| Support3 | 2.33 d-g | 1.53 e-i | | 1.49 a-g | 0.322 ab | | 75.05 c-i | 27.32 c-i | | | 8.82 ab | 38.52 d-h | |
| Mean separation within columns by LSD at 5% level. | | | | | | | | | | | | | |