Breeding and Selection of Apple Rootstocks to Match California Industry Needs

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Executive Summary:

Apple orchards throughout the United States are undergoing a foundational transformation to more productive and disease resistant rootstocks. Rootstocks are the foundation of a healthy and productive orchard. The California apple industry needs location and variety compatible recommendations with regards to newly developed rootstocks by the Geneva breeding program. The breeding program has been cooperating with the California Apple Commission, some California nurseries (Sierra Gold and ProTree) for the evaluation and development of a special set of apple rootstocks that is focused for the challenges faced by California Apple Growers which include compatibility with mechanization, per acre productivity, low chill climate, water and nutrient use efficiency, resistance to fire blight, tolerance to replant disease (a genetic alternative to methyl bromide fumigation), interaction with apple viruses, crown rot and wooly apple aphids. The

Geneva® apple . rootstock breeding program is the only one in the world that has delivered on these traits in other locations and is poised to conduct grower requested, on farm field trials to identify a set of apple rootstocks compatible with California specific needs. The breeding program cooperates with several California nurseries in order to develop clean nursery stock for propagation - the project includes a component of nursery stock development, evaluation of virus effects on apple rootstocks and micropropagation.

Project Benefit to Nursery Industry and California Apple Industry:

As it has done in other apple growing states like WA, NY, MI, PA, etc. the project will benefit the California apple nursery industry by developing localized, improved apple rootstocks and providing the virus free nursery stock to cooperating California nurseries. A change from traditional (ancient technology) to localized improved apple rootstocks has enabled other U.S. and world industries to increase their productivity by 25%-75%, decreased the quantity of fumigants used in the establishment of an orchard and saved millions of trees from the deadly fire blight disease. We expect the same impact for the California apple industry. A special attention to virus interaction with rootstocks will allow nurseries and apple growers to understand the effects of apple viruses on production and identify stocks that are symptomatic in the presence of viruses.

Objectives:

1. Develop on-farm field trials for diverse apple grower locations throughout California featuring novel and yet to be released apple rootstocks.

2. Monitor growth, productivity and nutrient absorption and study potential virus effects of Granny Smith on apple rootstocks.

3. Develop and provide virus clean nursery stock to California Nurseries of selected materials.

Workplans and methods:

Description of proposed field trials: 2020 On Farm Field Trial -three locations

In 2019 we consulted with the California Apple Commission (see attached letter of support) and drafted a plan to develop on farm field trials at three or more locations. While it takes two years to develop apple trees for a rootstock field trial we had an existing set of trees developed for other U.S. trials with material from ProTree and Sierra Gold nursery and grown at Sierra Gold nursery in Yuba City that were able to be allocate to start this
project. We are in the process of developing a second set of trials featuring a more complete set of already . released rootstocks and include control rootstocks like B.9, M.9 and newly released Geneva rootstocks G.213, G.890, G,969, G.202, G.41, G.935, G.814, G.222 and G.214. 2020 trees are grafted with Buckeye Gala and Granny Smith. Additional scion varieties will be selected in coordination with the California growers and CAC. The trees will be planted and managed by apple grower cooperators according to their management style.

Nutrient Uptake Determination

Apple frees are supposed to fill their canopy space by year 2 after planting (depending on rootstocks) When the trees are at a locally adapted state (2-3 years after planting) ten mid position leaves on new extension growth and ten fruit randomly distributed throughout the tree canopy will be harvested 80-90 days after bloom on all tree replicates of each field trial. Leaves and fruit will be oven dried, ground into powder arid a subsample will be shipped to the Great Lakes analysis lab for mineral analysis of several macro- and micro-mineral nutrients via inductively coupled plasma optical emission spectrometry. Another subsample will be analyzed using an X-Ray diffraction instrument to calculate relative concentration of nutrients. Soil samples will be collected from field locations from all research plots and will be analyzed for nutrients at a TBD lab. Leaf and fruit nutrient concentration values will be tabulated and analyzed with Minitab 18.0 and JMP 14.0 Pro statistical software packages; the rootstock genotype was treated as the main effect in a randomized complete block analysis. Rootstock genotype means will be used iri a multivariate analysis to generate correlation matrices and two-way similarity duster diagrams based on genotype and variable similarities.

Virus indexing and interaction with apple rootstocks

We will use a combination of RT PCR methods and deep sequencing to identify virus composition in the scions and rootstocks that were deployed in these trials. It is likely that Granny Smith is a carrier of latent viruses and virus like elements since it was very hard to source certified virus free wood of this variety. On the other hand, Buckeye Gala came from certified VF wood. Effects of virus interactions with rootstocks can be displayed by unusually poor growth of the trees relative to virus free material. Relative growth differences between Granny Smith and Buckeye Gala on the same rootstocks will be used as a phenotypic diagnostic tool.

Remote Growth measurements and yield characteristics

Using a phenotyping app called FieldBook (Figure 1) the grower or a technician will collect images of individual t.rees in the trial prior to harvest - image analysis will provide an estimate of the crop load on each tree and relative size. In year 5 of the trial when the trees are fully grown and established a full canopy, we will collect fruit from each individual tree and measure total yield for each rootstock on a per acre basis. Mean fruit weight (FW) will be calculated considering the total number of fruits and total yield per tree. Average fruit size will also be calculated as it is one of the main parameters for fruit quality. Cumulative yield (CY) per tree, yield efficiency (YE) and crop load (CL) of each scion-rootstock combination will be computed from the harvest data. Each winter tree size may be estimated using pictures from the FieldBook App when trees are bare. This will allow also the investigation of rootstock effects on tree canopy shape. The tree circumferences will be recorded at 30 cm above the graft union, and the trunk cross-sectional area (TCSA) will then be calculated.

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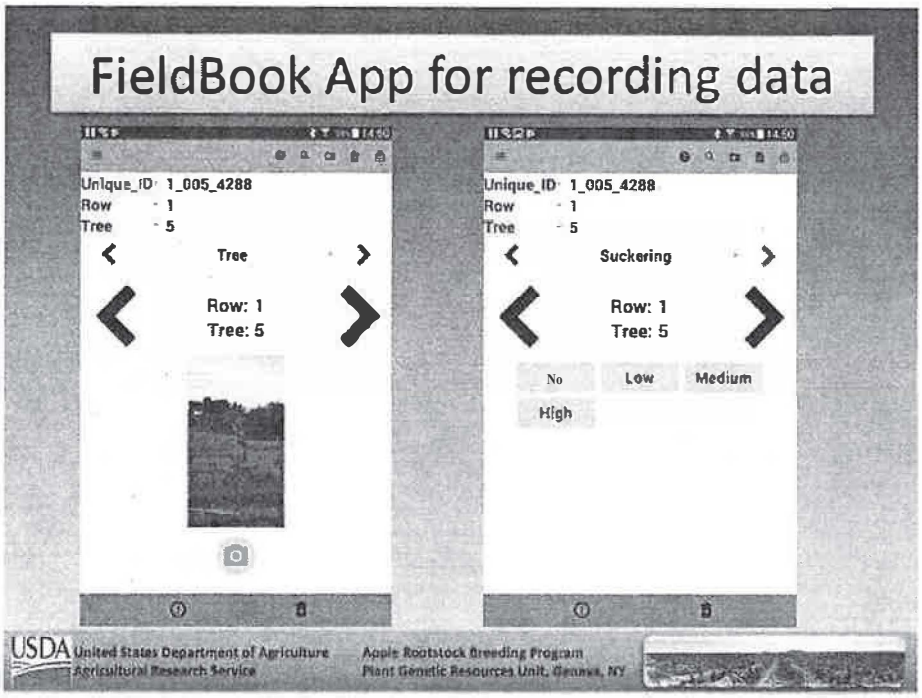

Figure 1. The FieldBook App (available in GooglePlay) is a phenotyping app compatible with most android devices (cell phones and tablets) and allows the collection of visual (properly named images by date, plot and tree number), quantitative, qualitative and voice data that can then be exported for secondary analysis in the form of tables or image files.

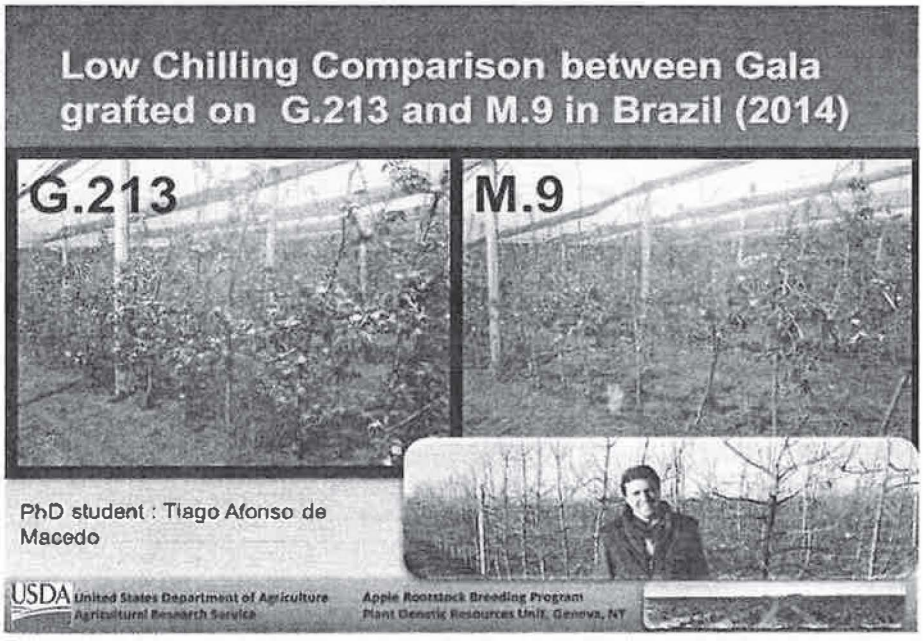

Figure 2. Example of an on-farm field trial in Brazil featuring a Geneva apple rootstock that decreases

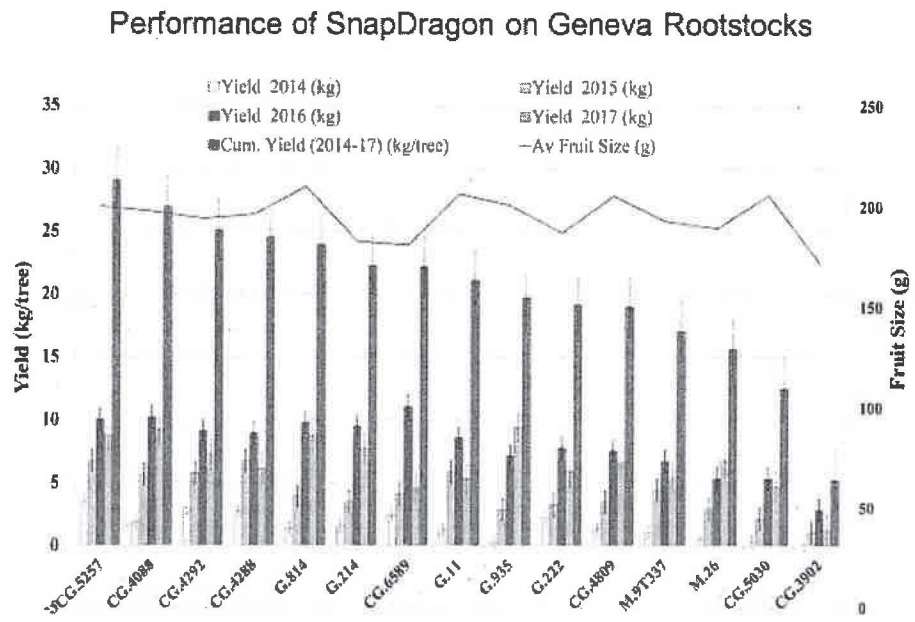

Figure 3. This type of information collected from an on-farm trial in NY state is an example of the valuable yield and performance information that can be obtained by local field trials.

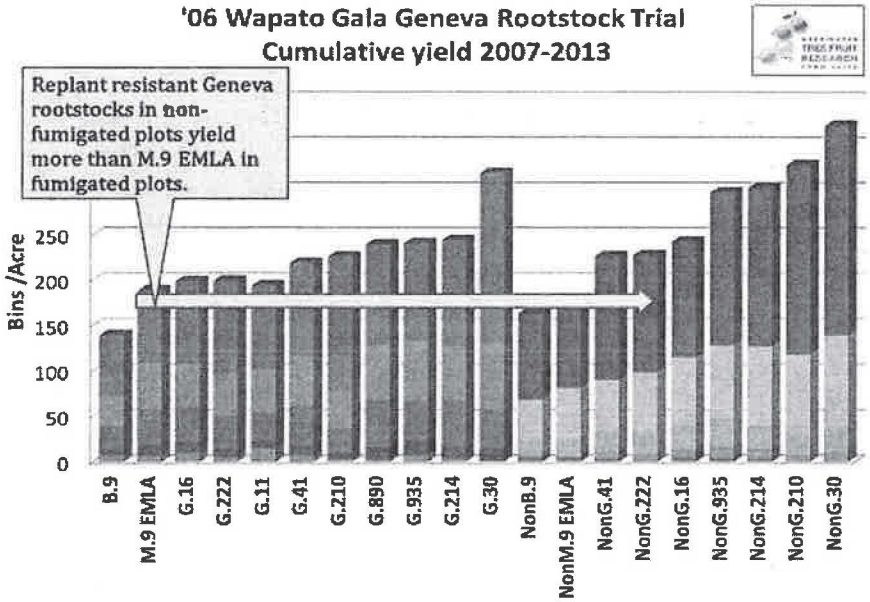

Figure 4. Yield data showing genetic yield potential of apple rootstocks in replant ground in an experiment in collaboration with the Washington Tree Fruit Research Commission planted in 2006 and like the ones proposed in this document.

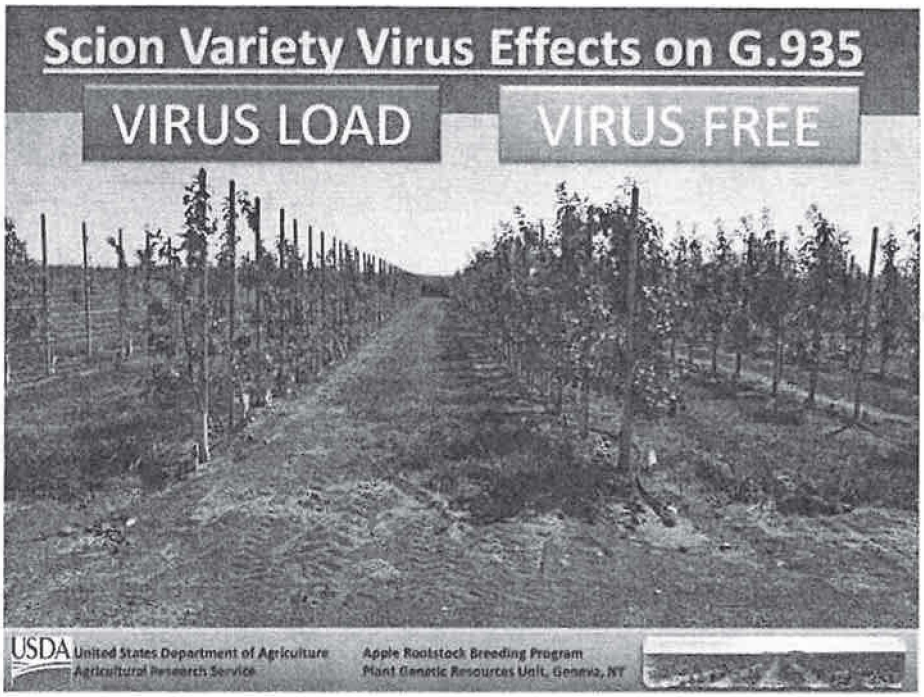

Figure 5. Effects of virus load on G.935 rootstocks. Same Honeycrisp scion variety grafted on all trees except the trees to the right were budded with certified virus free wood.

Project management and evaluation:

While the day to day decisions about field trial management will be the responsibility of each of the host farm managers and owners, the planning and coordination of data collection, analysis and reporting will be the responsibility of the project leader in Geneva, NY. All laboratory work will be conducted in Geneva, NY as we have ample experience performing all of the laboratory tasks proposed. Reporting will be done in both written and oral reports to the California Apple Commission (CAC), trade journals and grower associations. The CAC will evaluate progress and provide necessary feedback on the progress of the project.