Leveraging genomic resources to breed a difficult perennial crop: apple rootstocks

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ABSTRACT

Rootstocks are the foundation of a healthy and productive orchard. As such, the choice of a rootstock can influence the productivity and profitability of an orchard in a very significant way. Rootstock performance is highly correlated with the genetic potential of such rootstock to provide anchorage, explore the soil profile, absorb and transfer nutrients to the scion, adapt to pedo-climatic conditions, tolerate extreme weather events, resist or cope with pathogens, propagate efficiently and impart positive architectural properties to the scion – like vigor control and precocity. The inheritance and control of all these desirable characters is quite complex making breeding (the action of combining high performance traits in the same rootstock) quite challenging. Recent advances in genomic technologies are allowing more efficient, and informed way of selecting new rootstocks during the breeding process. Furthermore, breaking down complex traits like tree vigor into component traits (hormonal transport, nutrient uptake and transport, root architecture, water use efficiency) and further characterization of the inheritance of these component traits can simplify the understanding of complex traits and improve the breeding process and outcome.

In the Geneva® breeding program we have been studying root architecture, nutrient uptake and translocation, inheritance of gene expression to better characterize breeding populations and select parents and seedlings for the next generation of apple rootstocks. We present data relating to these traits and how they are associated to good performance of released and elite stage apple rootstocks.

Relevant Manuscripts


Breeding Apple Rootstocks

Advantages

- Grafting
- Repeated measures (years)
- Grafts have a cumulative 300+ years of trial data
- High clonal replication
- Collected more than 125 phenotypic traits on one population
- Ability to study clone x environment interaction in detail
- Very high genetic diversity

Disadvantages

- Very Long Generation Times
- Measure most meaningful traits on different grafted genotypes – indirect measurements
- Rootstock-scion interactions
- Root phenotypes difficult to measure

Developing a breeding strategy

-omics Assisted Breeding

Two Tiered Approach

Leveraging Genetic and QTL Mapping

Combining Phenomics and Gene Expression

Leveraging Next Gen Sequencing

Leveraging RNAseq

SIDEBAR – What are apple rootstocks?

1. The rootstock mother plants are layered with saw-dust in a stoolbed to generate rooted rootstock shoots

2. The rooted rootstock shoots are harvested from the mother plant and planted in a nursery

3. A bud from a scion variety like Gala is grafted on the rootstock

4. The scion bud grows into a shoot and then into a mature apple tree. The rootstock will influence the productivity, size and precocity of the apple tree.