Understanding Root Traits of Rootstocks, and Their Potential Impact on Tree Health in high-density orchards

Plant Pathology and Plant-microbe Biology, Cornell University

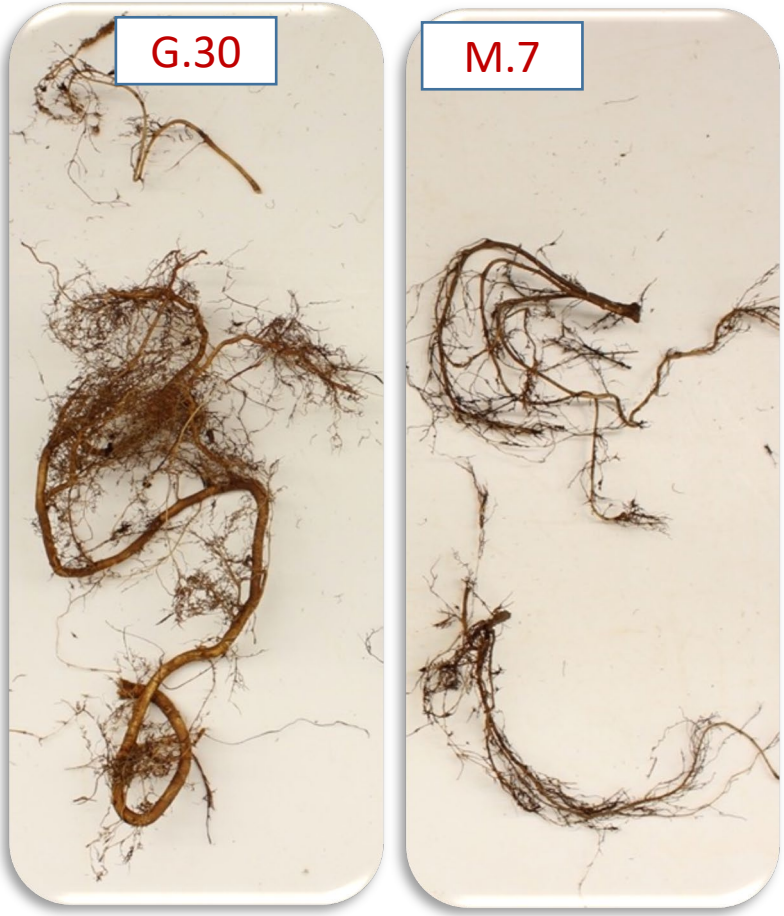
An apple tree in a commercial orchard

Rootstock and scion is forced to make a deal to live together through all ups and downs of life

Few sizes fit all: Are rootstocks suitable for all production systems, environments and scion cultivars?

Although commercial rootstocks differ for many traits

- Great variation in soil composition
- Environmental variables
- Pathogen strains
- Compatibility of scion cultivars
- Orchard management systems

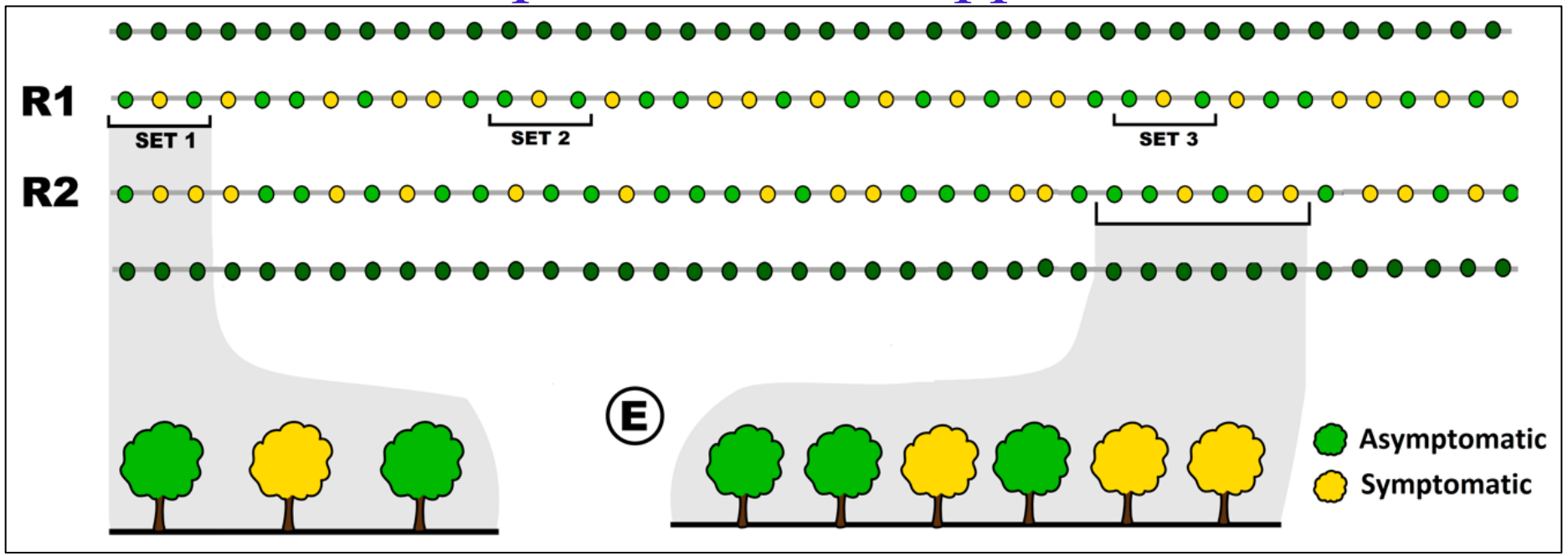


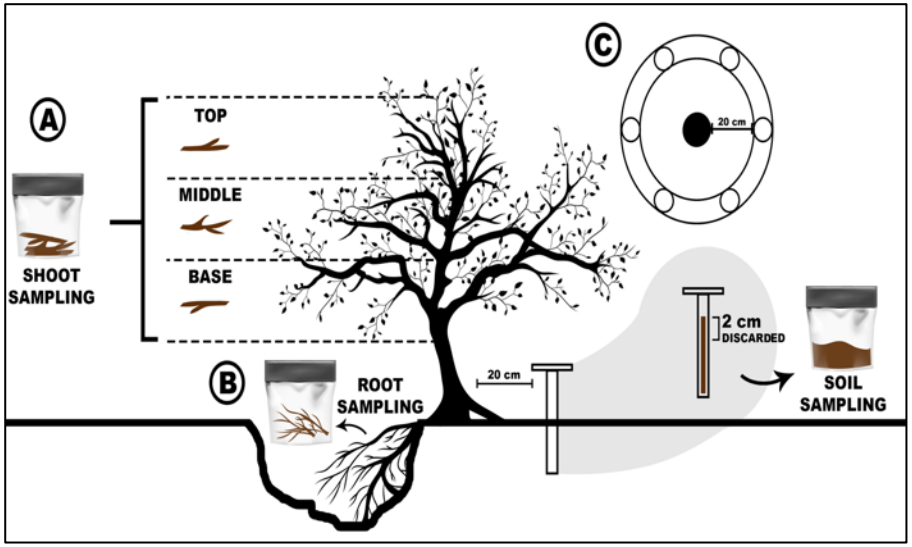
Root traits of 'M.7' rootstocks obtained from the same nursery differ significantly.

Breeding apple rootstock for specific traits can take a long time

Potential role of weather, soil and plant microbial communities in rapid decline of apple trees

Singh et al. 2019a



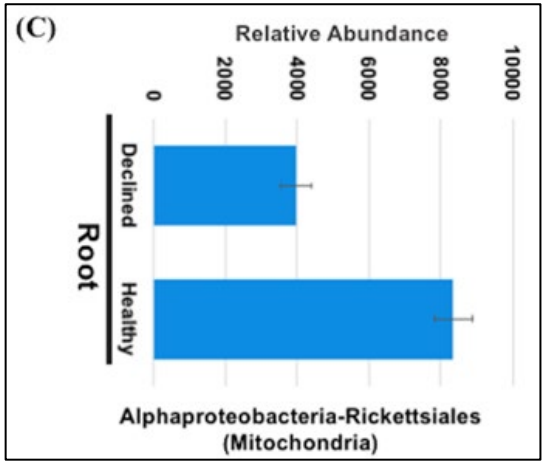


Potential role of weather, soil and plant microbial communities in rapid decline of apple trees

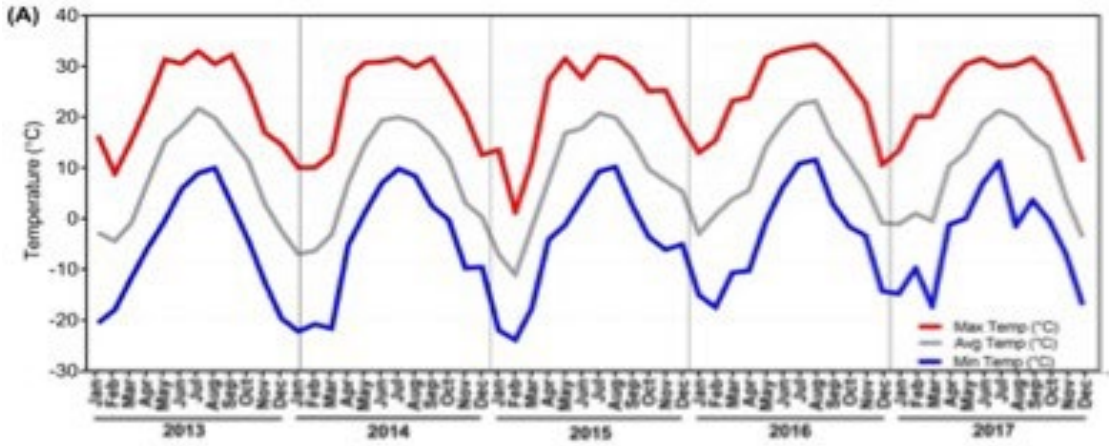
Singh et al. 2019a

- ✓ Six latent viruses
- ✓ Physical properties, and chemical composition of the bulk soil
- ✓ Weather data 2013 to 2017
- ✓ Visual symptoms of outer and internal wood decay
- ✓ Fungal and bacterial communities

Poor root system with very few fine & deep roots.



Reduction of drought associated bacterial species in declined tree roots



Cold Jan, Feb (the third-coldest February on record in the region since 1934) & March 2015, and drought in 2016.

Based on our results, we concluded ‘Rapid Apple Decline’ is a complex syndrome with many potential causes!

Therefore, we considered a targeted approach focusing on one potential cause at a time rather than a systems-level approach for this project.

“The tight space in high-density plantings creates intense competition for nutrients and water, especially for inadequate root-systems, which are thus unable to upkeep heavy crop, foliage, and biomass under extreme weather. These negative effects can be aggravated in soils with poor water holding capacity”

USDA-CARE Project: Root traits and rapid decline of apple trees in high-density orchards

Establishing the role of root traits of two major rootstocks in the rapid decline of apple trees in high density orchards.

Assessing the influence of viruses on root traits of apple trees grafted onto two major rootstocks in high density orchards.

Characterization of root traits and root growth rate over time in controlled conditions for optimal spacing and resource uptake for high density orchards.

1. Commercial orchards

2. Experimental orchards

1. Commercial orchards

Orchard A

Honeycrisp on M.9Nic29
Planted in 2017
1.25m x 3m spacing
Sandy-loam soil

Orchard B

Fuji on B.9
Planted in 2013
1.5m x 4m spacing
Loam soil

Establishing a consistent decline rating system

0

No decline

1

Slight decline

2

Moderate decline

3

Severe decline

4

Dead

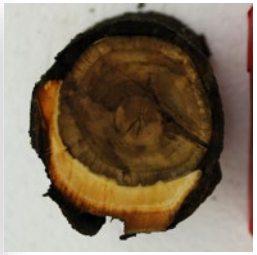
Tree vigor measurements and sample collection for root system evaluations:

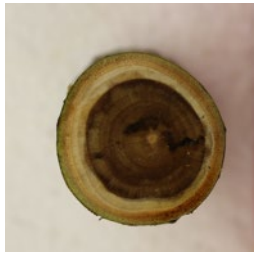
1 2 3 4

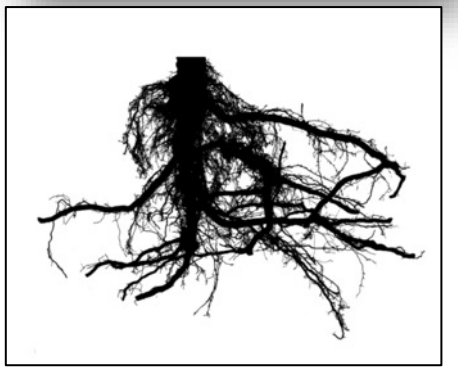
Tree vigor measurements → **Shoveling root systems** → **Sample collection**

Photos: Elizabeth Tee

Root trait analysis: ImageJ and RhizoVision and Internal necrosis in trunk and rootstock:







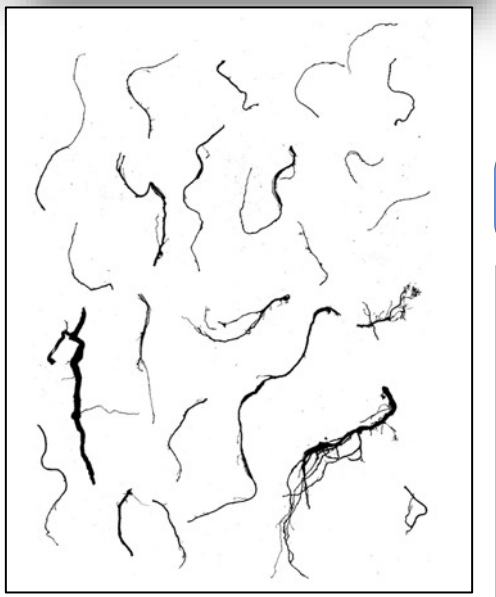


Image rootsystem

- Root system Depth and Width
- Number of large
- Root Surface area

Scan individual roots

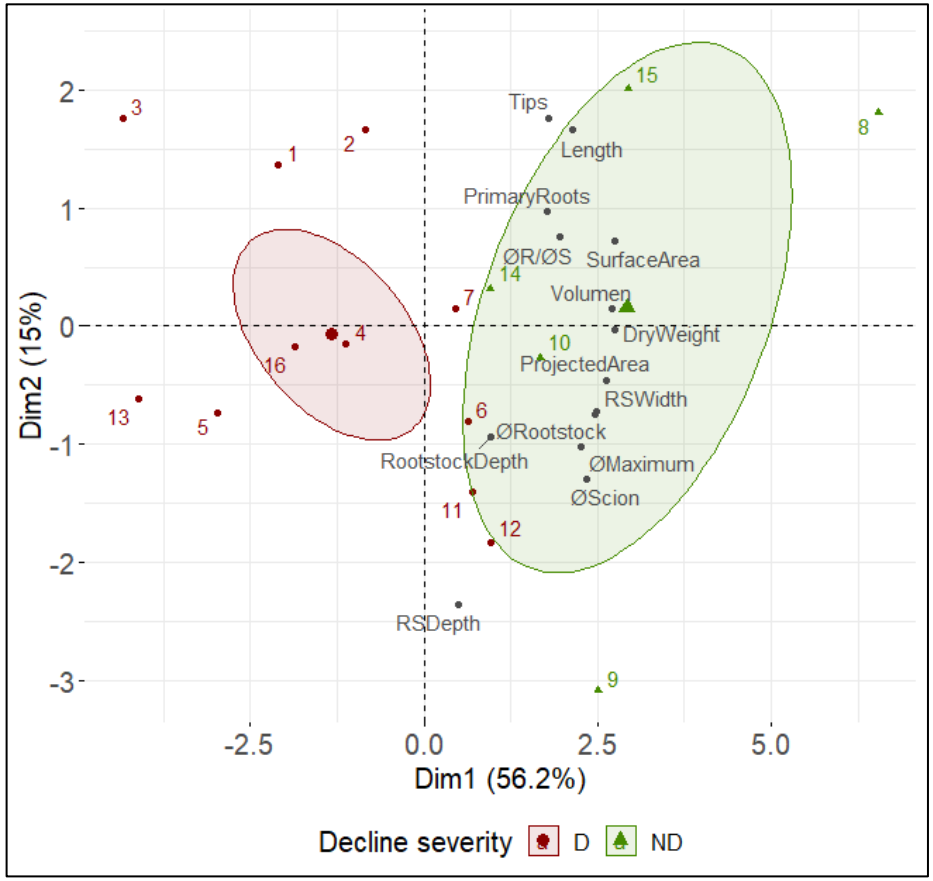
- Root length, area, root branching, volume
- Diameter and number of fine roots, and large roots

Analysis of the internal necrosis

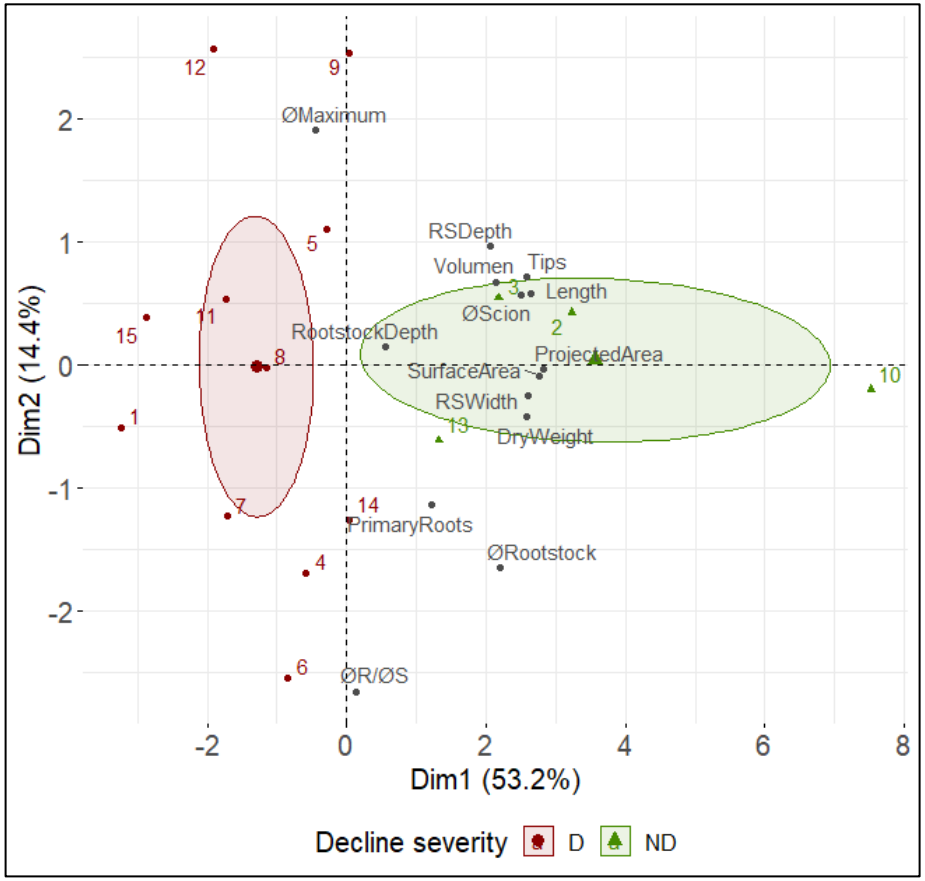
Percentage of necrosis

Root trait of rootstocks in commercial orchards

Orchard A

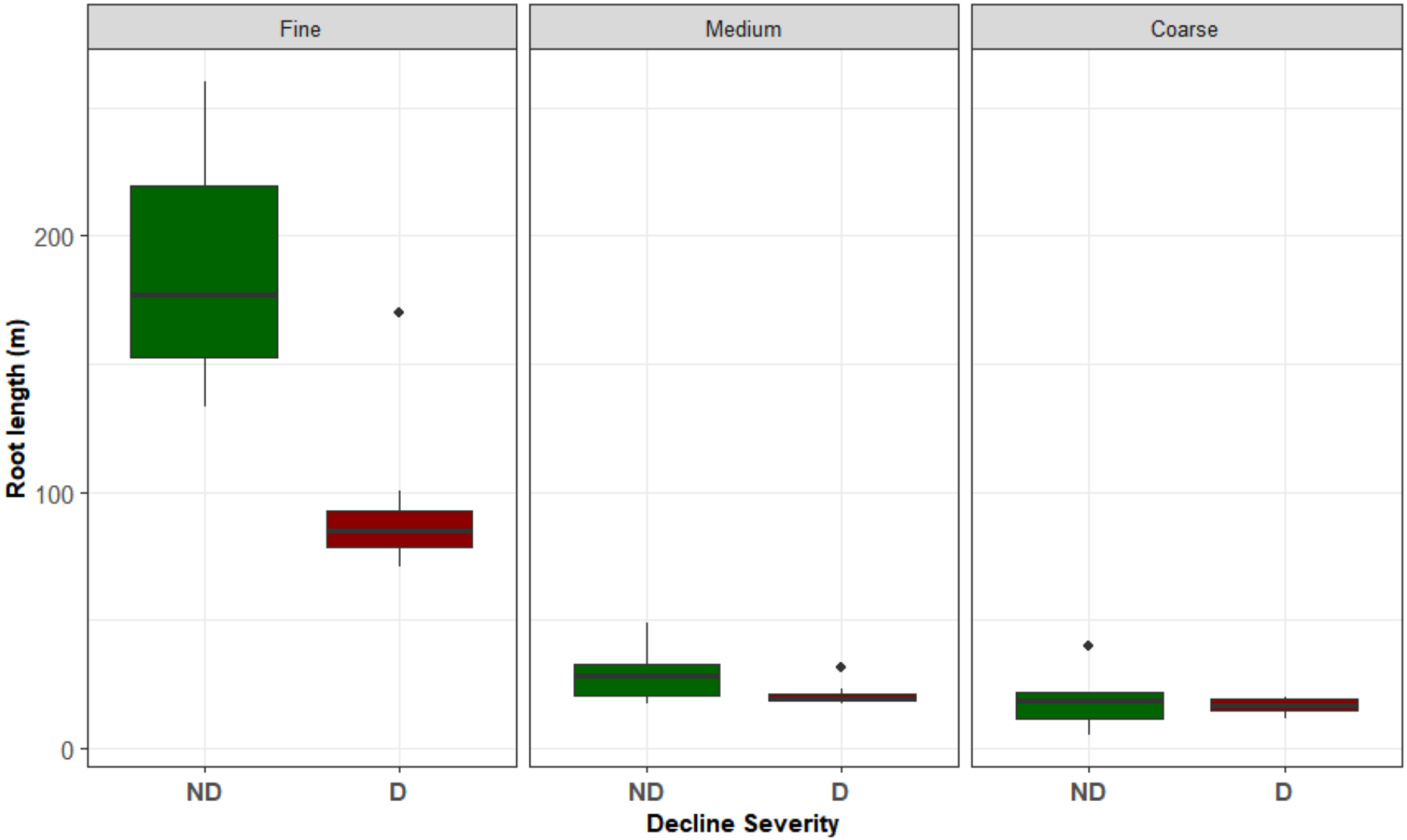


Orchard B



- Declining and non-declining trees could be clearly differentiated based on root traits.
- Non declining trees are positively correlated with roots traits (Dry weight, rootstock depth, Volume, Length and Rootstock trunk diameter) and had more robust root system than declining trees.

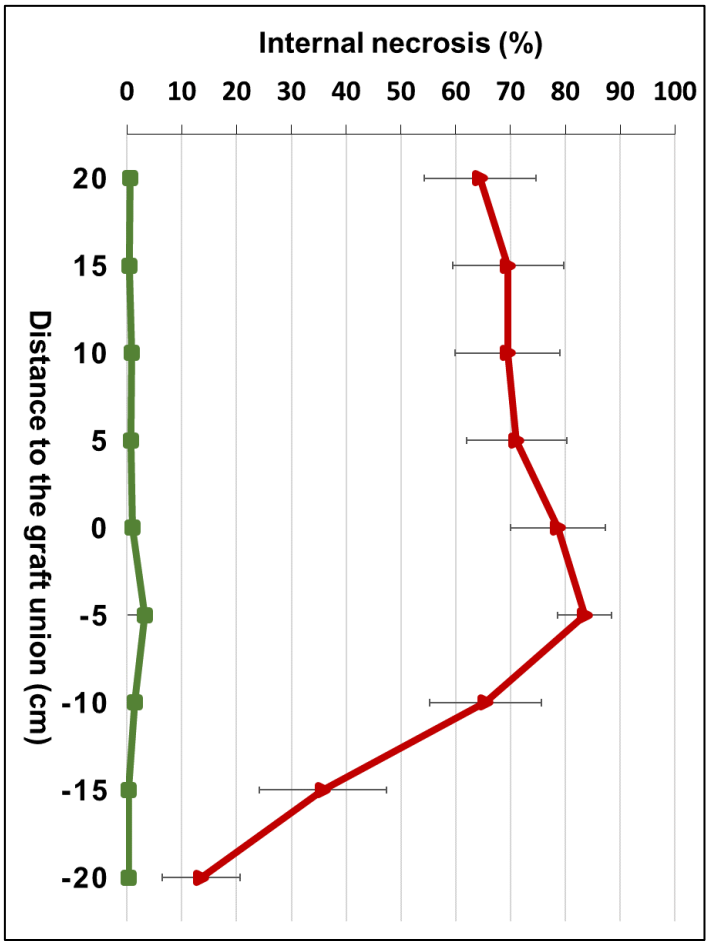
Root trait of rootstocks in commercial orchards

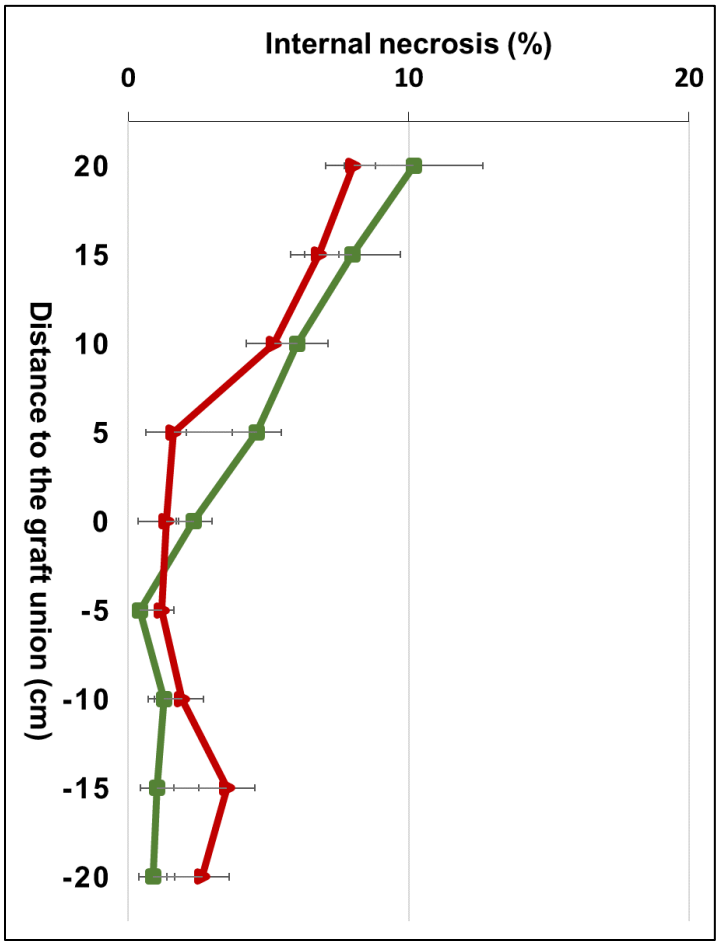


- Fine roots were more abundant than medium or coarse roots.
- Non-declining trees has greater root length than declining trees.

Internal necrosis in trunk and rootstock:

Orchard A ND D **Orchard B**





- Necrosis is most severe at the graft union indicating that graft union may be weak in declining trees (at least in Orchard A).

Major takeaways so far

- ✓ In both orchards, declining trees have shown a smaller root system in term of total root length than non-declining trees.
- ✓ Not all parameters have shown the same relationship with the declining severity between orchards, so this RAD phenomenon in different orchards could be induced by different causes.
- ✓ Necrosis is most severe at the graft union indicating that graft union may be weak in declining trees (at least in Orchard A).
- ✓ The relationship between RSA and RAD needs to be further explored.

2. Experimental orchards

- **Rootstock-Scion combinations**

1. G.935 self grafted
2. Honeycrisp onto G.935
3. M.9 Nic29 self grafted
4. Honeycrisp onto G.935

- **4 block x 10 replicates/block planted in May 2021**

Measurements:

1. Trunk diameter (Scion and rootstock)
2. Plant height
3. Shoots number and length

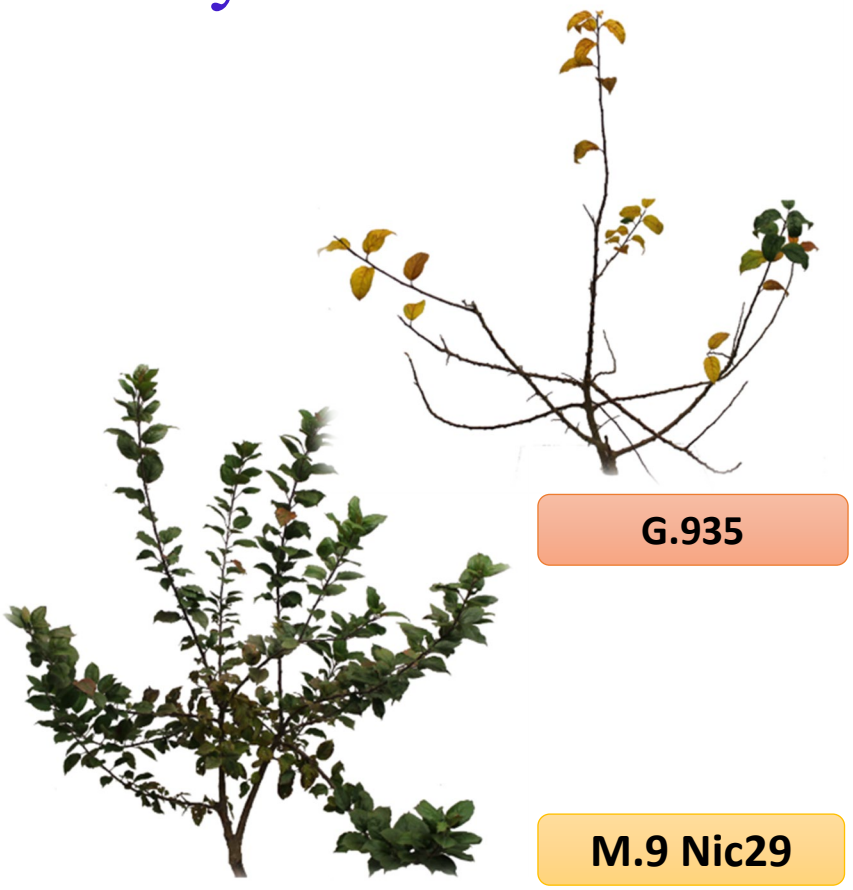
Root system sampling:

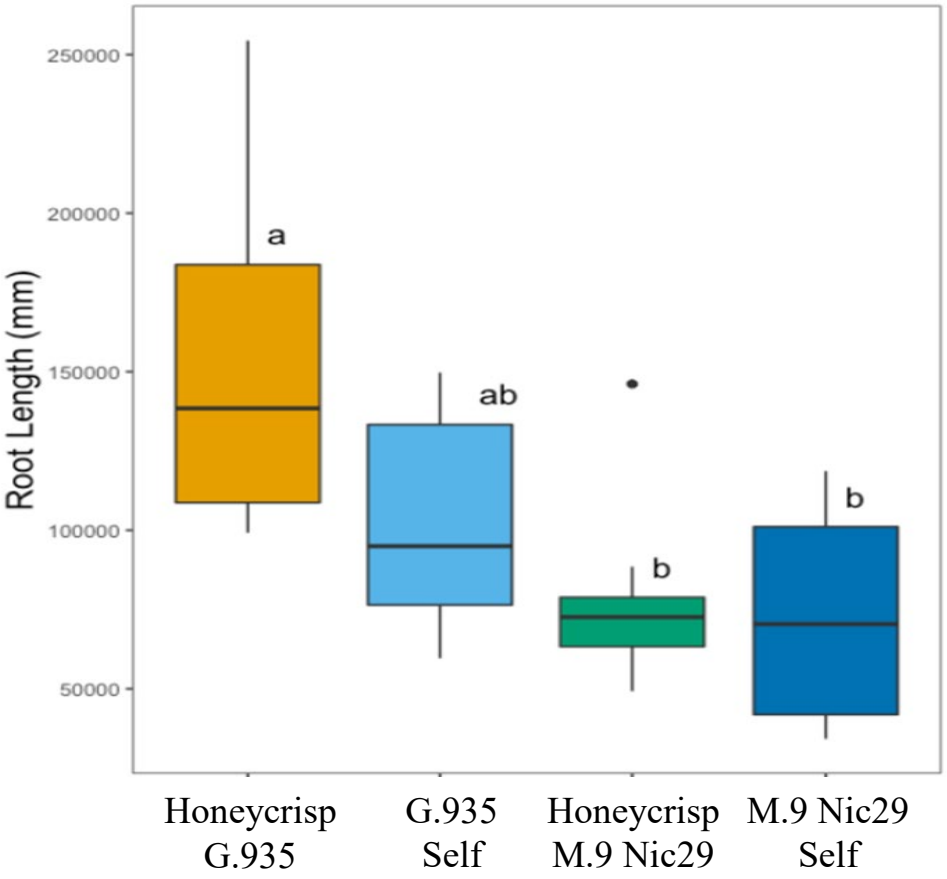
12 months after planting (Done)
18 months after planting (Done)
24 & 30 months after (future)

Sampling of rootstocks, and root trait evaluation

- Root washing
- Pictures of entire rootsystem
- Scanning of shaved off roots
- Image analysis with ImageJ and RizhoVision

Preliminary results: Root trait of rootstocks in high-density research orchard





- Tree architecture and leaf senescence varies greatly between G.935 and M.9 Nic29 rootstocks, possibly impact their root characteristics.
- G.935 rootstock has more vigorous root system than M.9 Nic29 rootstock.
- G.935 with Honeycrisp has greater root length than M.9 Nic29 with Honeycrisp.

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Thank you for attention!
Questions?