# Rootstock propagation method–How much does it matter?

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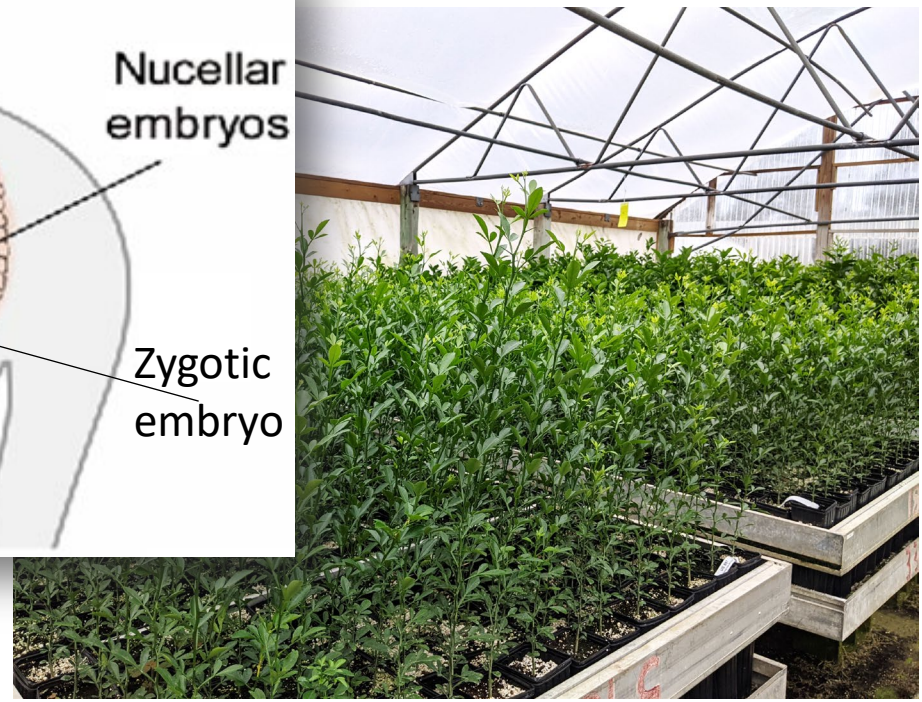
# Seed propagation



**Nucellar embryony (polyembryony)**

Genetically identical embryos develop from the nucellar tissue

# Cuttings and tissue culture propagation

*Photo credit: Beth Lamb, Phil Rucks Nursery*

Both methods produce genetically identical plants

# Tissue culture propagation

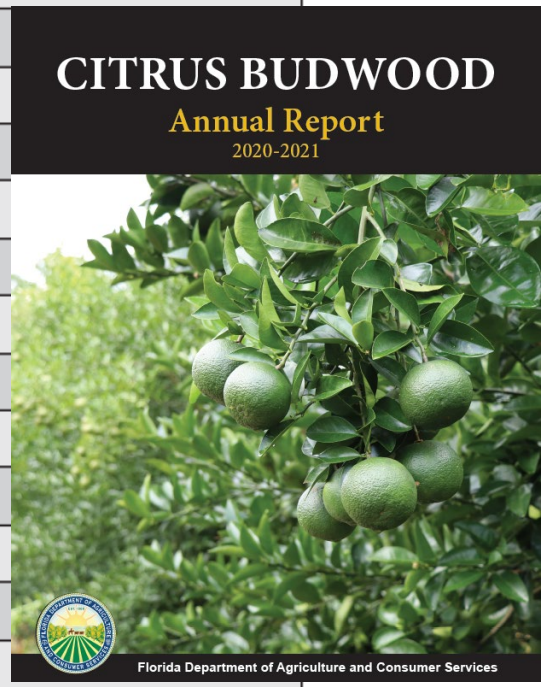
Fast year-round production of uniform plants

# Recent rootstock releases

| Rootstock | Parentage | Released | True-to-type |
|---|---|---|---|
| US-1279 | ‘Changsha’ x ‘Gotha Road’ | 2014 | 0 |
| US-1281 | ‘Cleopatra’ x ‘Gotha Road’ | 2014 | 0 |
| US-1282 | ‘Cleopatra’ x ‘Gotha Road’ | 2014 | 0 |
| US-1283 | ‘Ninkat’ x ‘Gotha Road’ | 2014 | >90% |
| US-1284 | ‘Ninkat’ x ‘Gotha Road’ | 2014 | >90% |
| US SuperSour 1 | Pummelo x ‘Cleopatra’ | 2018 | 0 |
| US Supersour 2 | TF x (SO x *C. ichangensis*) | 2018 | TBD |
| US SuperSour 3 | ‘Sunki’ x US-802 | 2018 | TBD |

# Top 15 Rootstocks 2020-2021

| | 2020 | # Budded | 2019 | 2018 | 2017 | 2016 |
|---|---|---|---|---|---|---|
| 1 | US-942 | 1,285,560 | US-942 | US-942 | Swingle | Kuharske |
| 2 | Kuharske | 841,448 | Kuharske | Swingle | US-942 | X-639 |
| 3 | X-639 | 678,095 | X-639 | Kuharske | X-639 | |
| 4 | Swingle | 468,558 | Swingle | X-639 | Kuharske | |
| 5 | Own Root | 408,793 | US-897 | Sour Orange | Sour Orange | |
| 6 | US-812 | 296,664 | US-812 | US-802 | US-802 | |
| 7 | Sour Orange | 176,322 | Sour Orange | Volkamer | US-897 | |
| 8 | US-897 | 160,288 | US-802 | US-812 | UFR-04 | |
| 9 | Volkamer | 135,977 | Volkamer | US-897 | US-812 | |
| 10 | US-802 | 119,887 | C-54 | Rough Lemon | C-35 | |
| 11 | Rough Lemon | 57,941 | Rough Lemon | C-35 | Cleopatra | |
| 12 | C-35 | 39,142 | UFR-04 | UFR-04 | Volkamer | |
| 13 | C-54 | 26,993 | C-35 | UFR-17 | UFR-03 | |
| 14 | Poncirus trifoliata | 18,106 | C-57 | Poncirus trifoliata | C-22 | |
| 15 | UFR-04 | 17,892 | US-1777 | US-1516 | Carizzo | Rough Lemon |




| Seed | Tissue Culture | Rooted Cutting |
|---|---|---|
| 38 different rootstocks used | 22 different rootstocks used | 17 different rootstocks used |
| 3,550,947 propagations | 650,090 propagations | 208,637 propagations |
| Top Seed = Kuharske | Top Tissue Culture = US 942 | Top Rooted Cutting = US-942 |
| (790,907 Propagations) | (583,560 Propagations) | (60,899 Propagations) |

# Objectives

## Short-term (nursery)

- Evaluate plant traits during the nursery stage:

## Long-term (field)

- Evaluate root structure, survival, and field performance during the early years and throughout the productive years.




# Cuttings propagation

- Starting material: single node stem cuttings from 2-5-month-old branches
- Rooting was stimulated by applying rooting powder (Hormodine) to the basal end of the cutting
- Cuttings were maintained shaded and on an automated mist bench until acclimated

Bowman and Albrecht 2017. Scientia Horticultura 225:681-688

# Tissue culture (TC) propagation

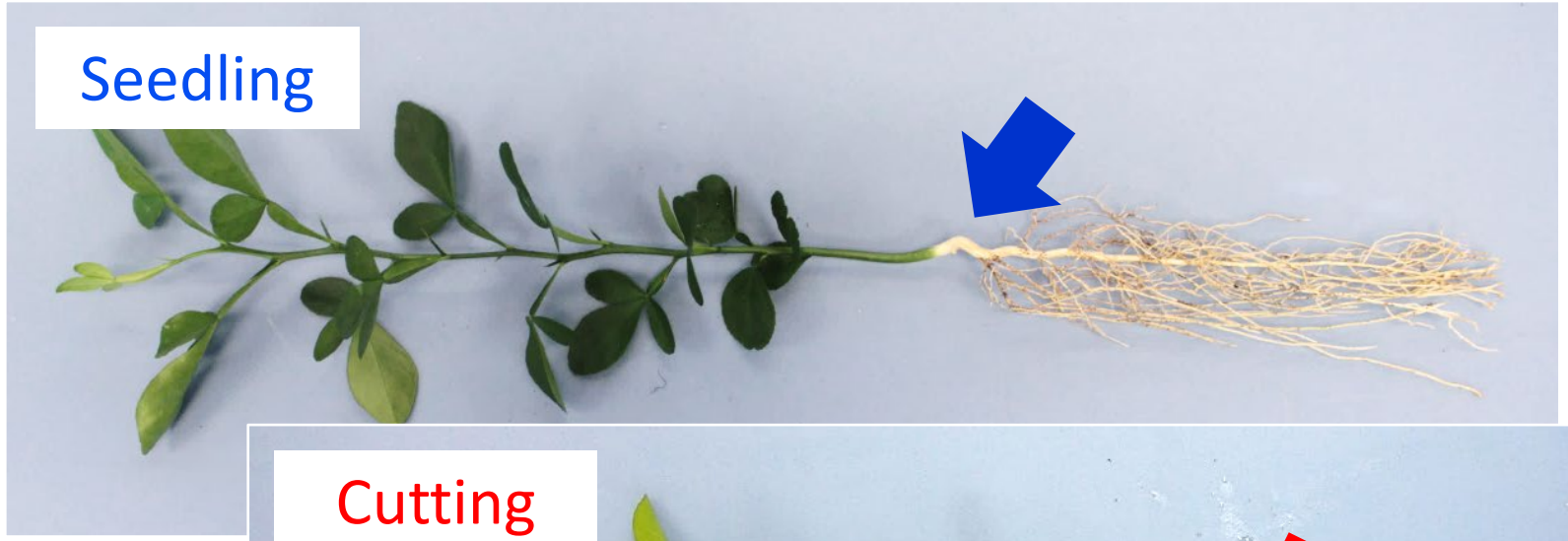
- Starting material: buds from mature disease-free and true-to-type plants
- Culturing on agar nutrient medium (composition proprietary)
- Sub-culturing to generate multiple shoot clusters
- Separation into individual shoots and planting in potting medium

*Photo credit: Beth Lamb, Phil Rucks Nursery*

Albrecht et al 2017. Hort Science 52(11): 1569-1576

# NURSERY

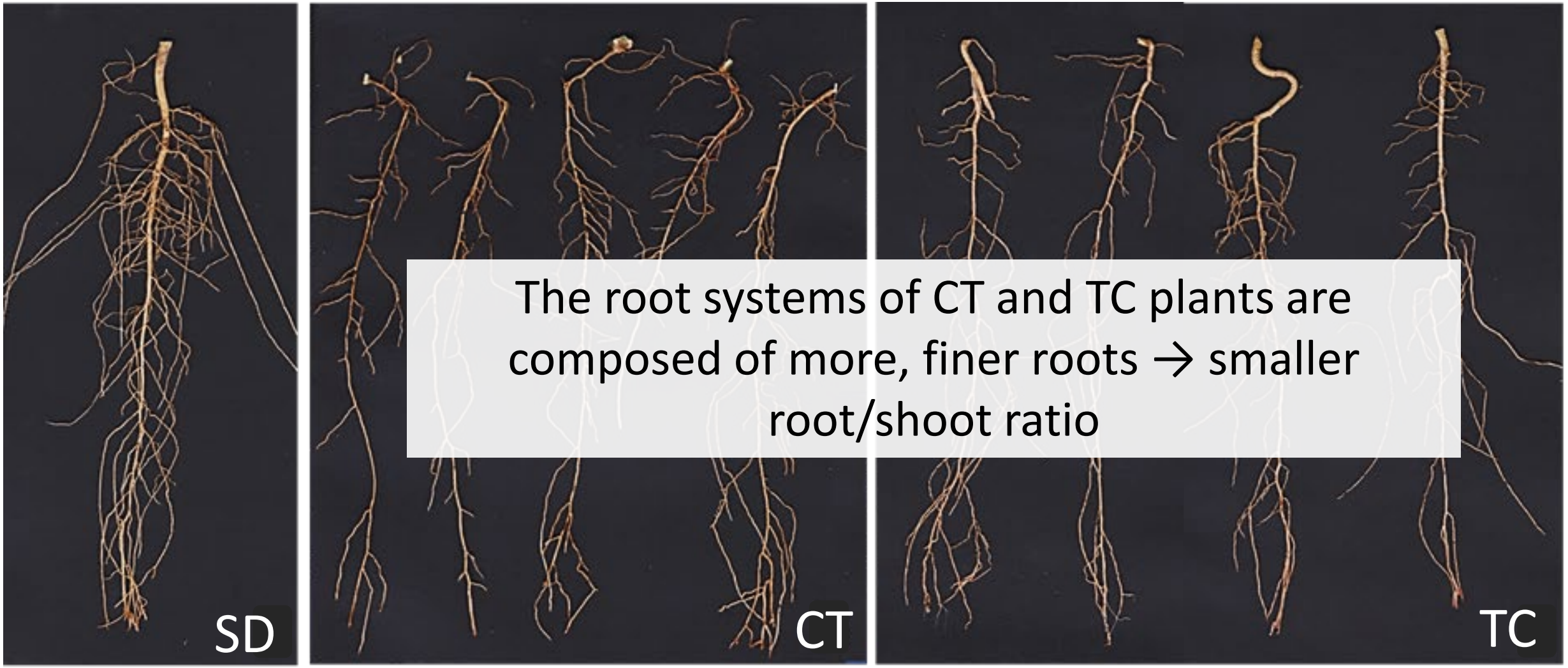
# Root system differences






Adventitious root systems

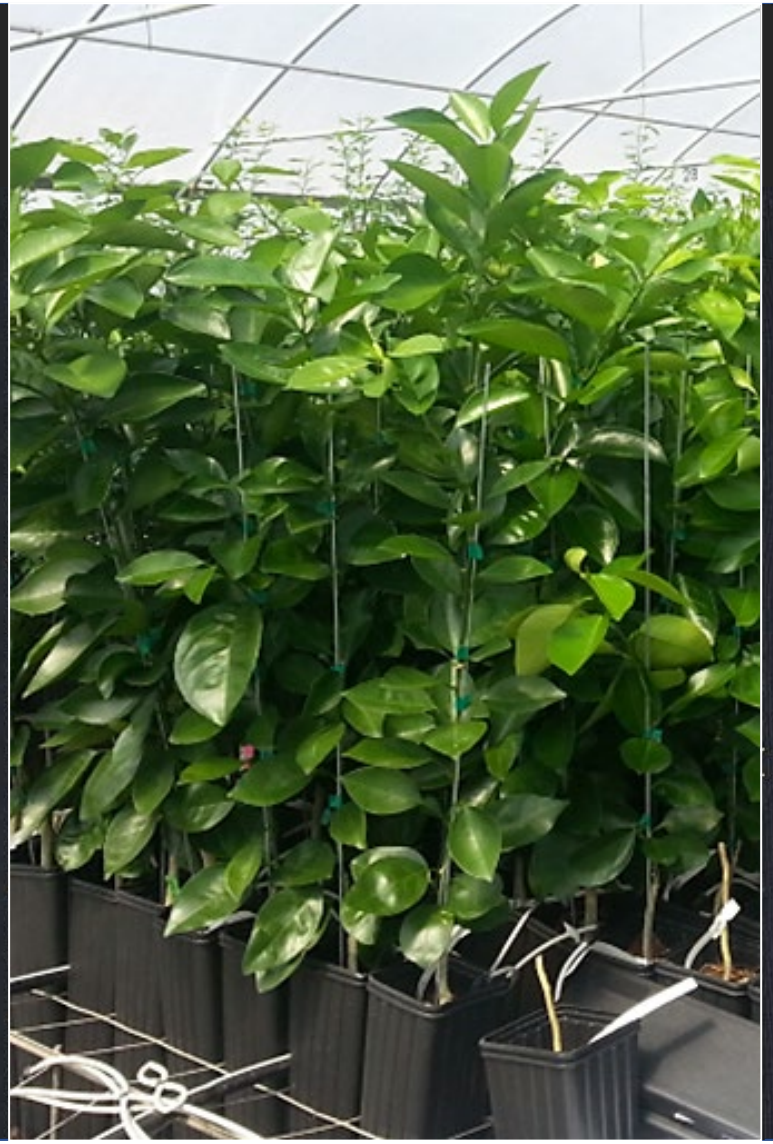
# Root system differences




The root systems of CT and TC plants are composed of more, finer roots → smaller root/shoot ratio

Albrecht et al 2017. Hort Science 52(11): 1569-1576

# Field-ready grafted trees

# Root mass fractions

| | Number of primary roots | Large size root mass (%) | Medium size root mass (%) | Fibrous root mass (%) |
|---|---|---|---|---|
| SD | 1.4 c | 55.8 a | 20.6 b | 23.6 |
| CT | 4.9 a | 32.4 b | 40.3 a | 27.3 |
| TC | 3.6 b | 42.8 b | 34.2 a | 23.1 |
| | *** | *** | *** | NS |

Root system differences persist in the field-ready plants

Albrecht et al. 2020, HortScience 55(5):729-737

# Biomass distribution

| | R/S biomass ratio | SLA ($cm^2/g$) | Leaf mass (%) | Stem mass (%) | Root mass (%) |
|---|---|---|---|---|---|
| SD | 0.384 a | 163.4 | 26.0 | 46.3 b | 27.7 a |
| CT | 0.310 b | 157.8 | 24.7 | 51.8 a | 23.5 b |
| TC | 0.330 b | 160.9 | 24.9 | 50.6 a | 24.6 b |
| | *** | NS | NS | *** | *** |

Differences persist in the field-ready plants

Albrecht et al. 2020, HortScience 55(5):729-737

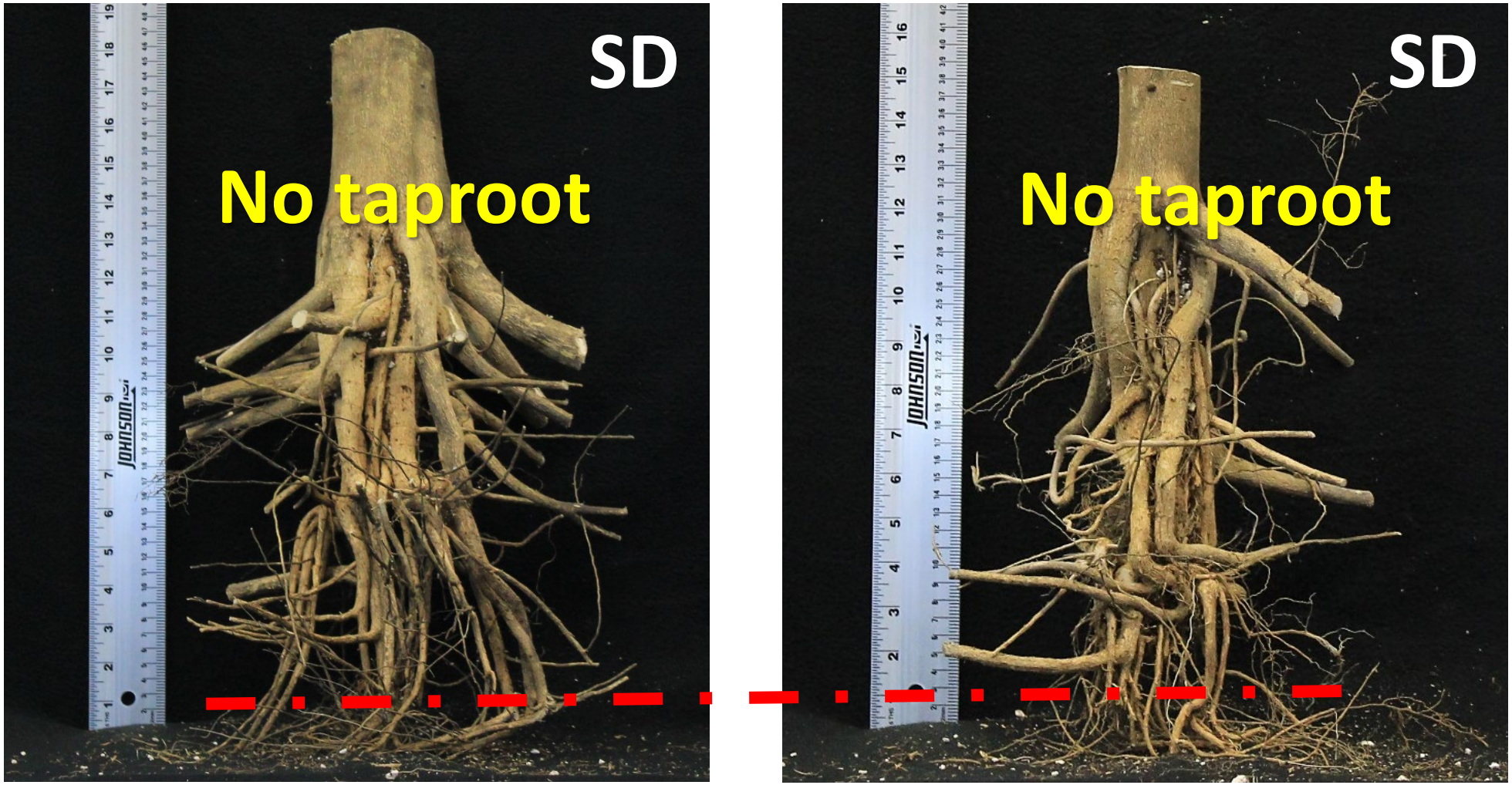
# FIELD

# Airspade tree excavations

Pokhrel et al. 2020, HortScience 56 (2), 163-172

Shallow root systems–no taproot, regardless of the propagation method

# Root crown analysis



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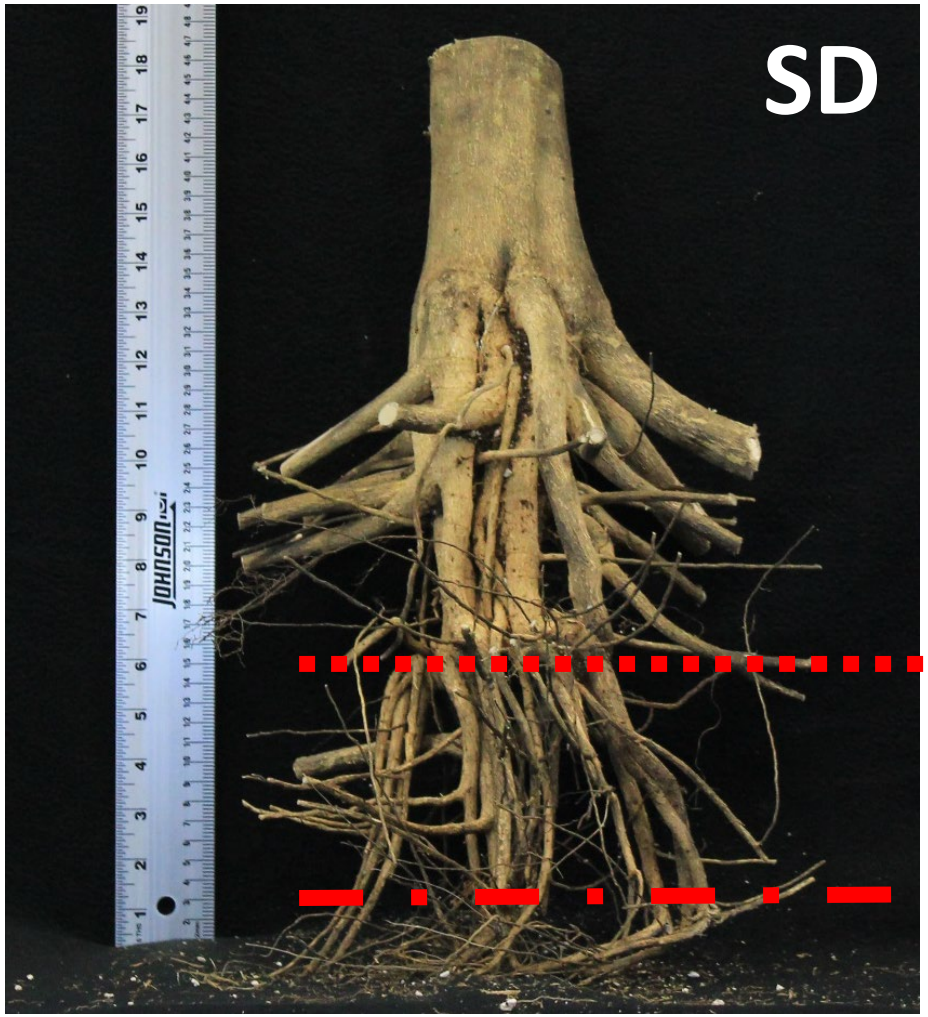
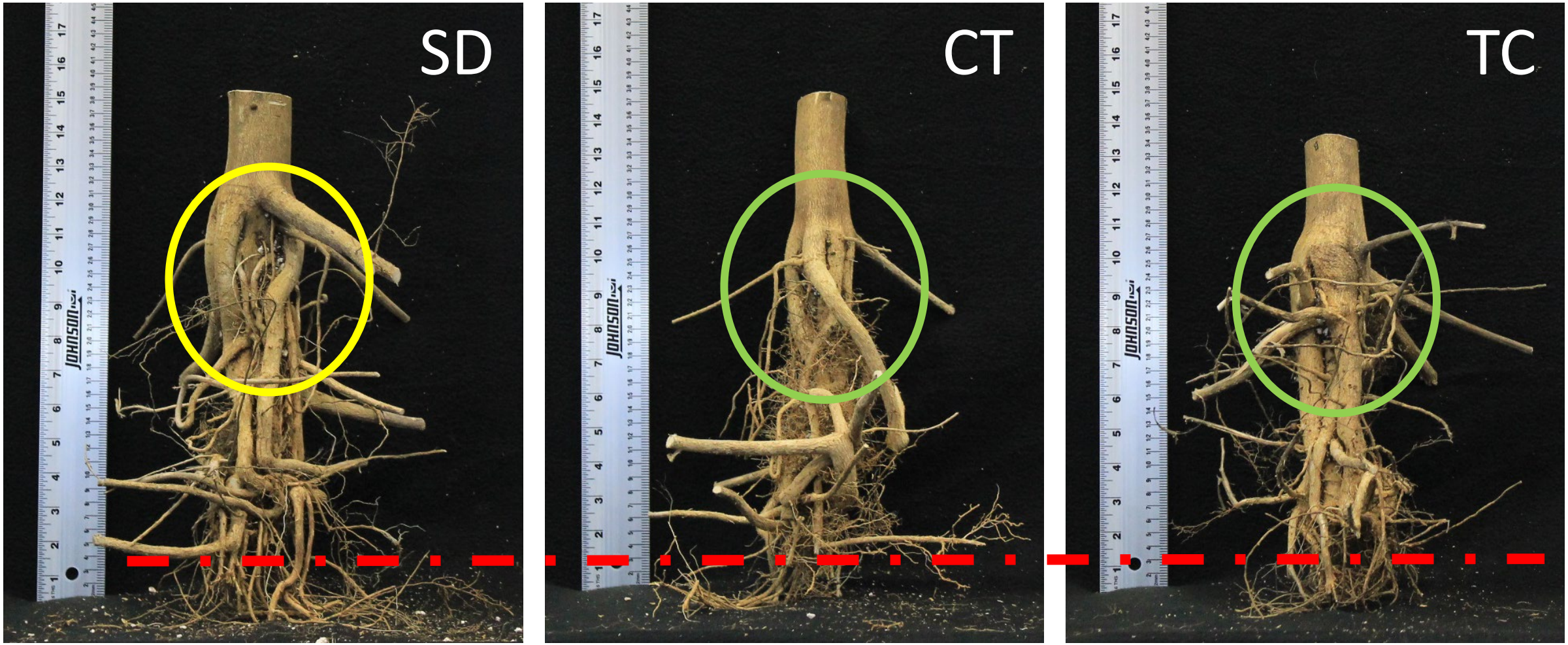


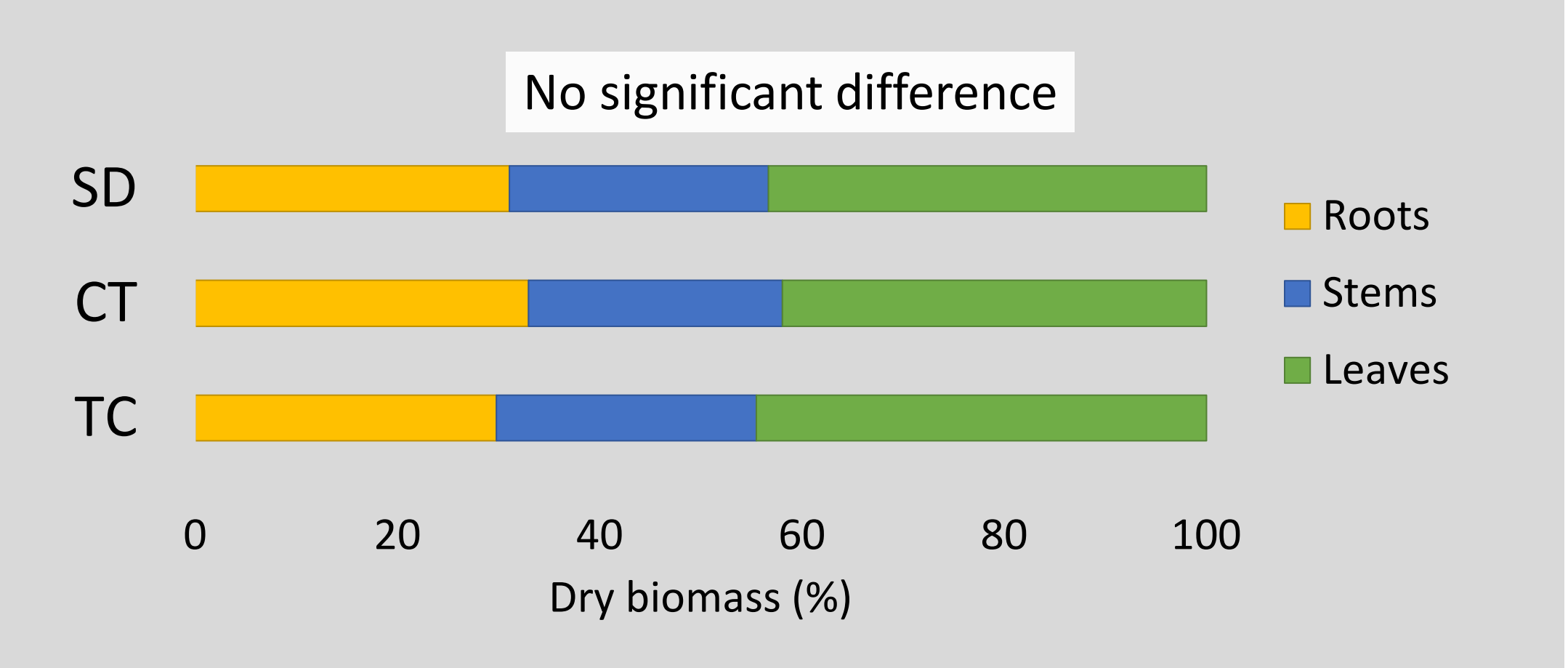


# Root crowns



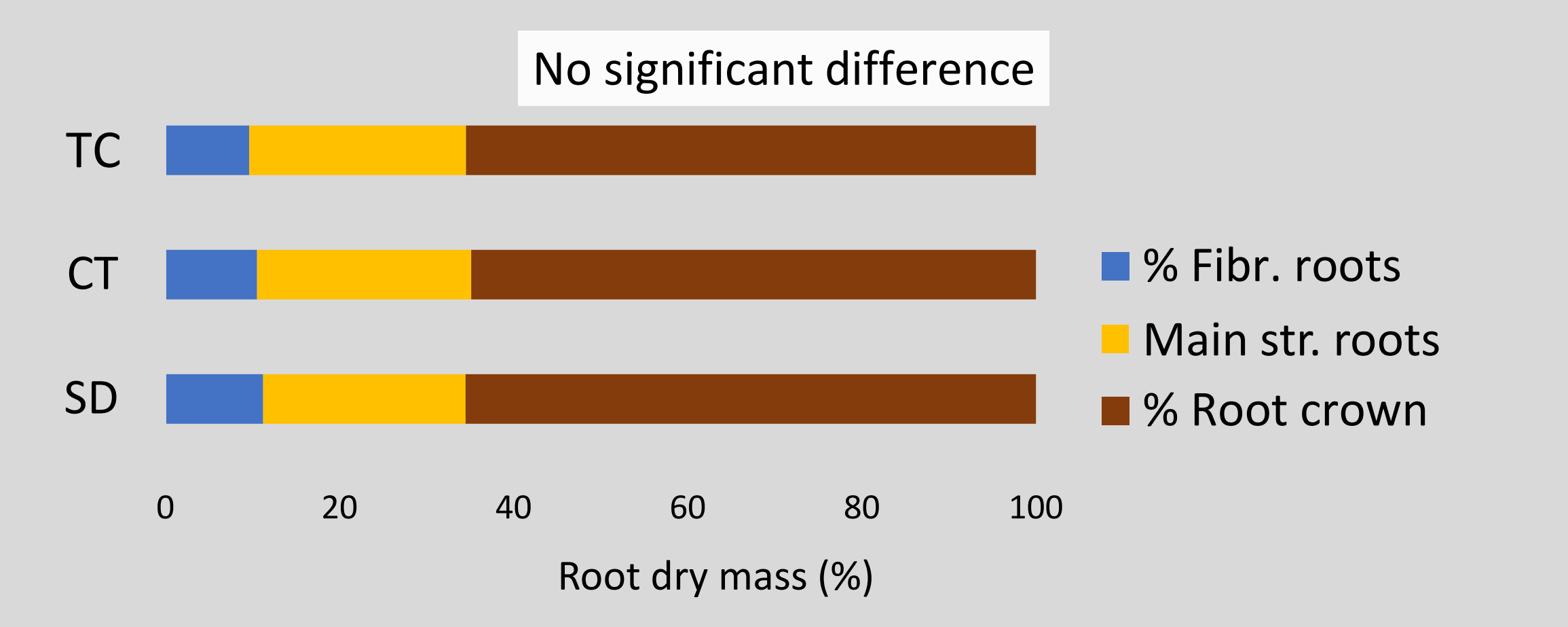

Root system differences are less noticeable after 2 years of field growth

# Biomass distribution




The propagation method did not influence the tree biomass distribution

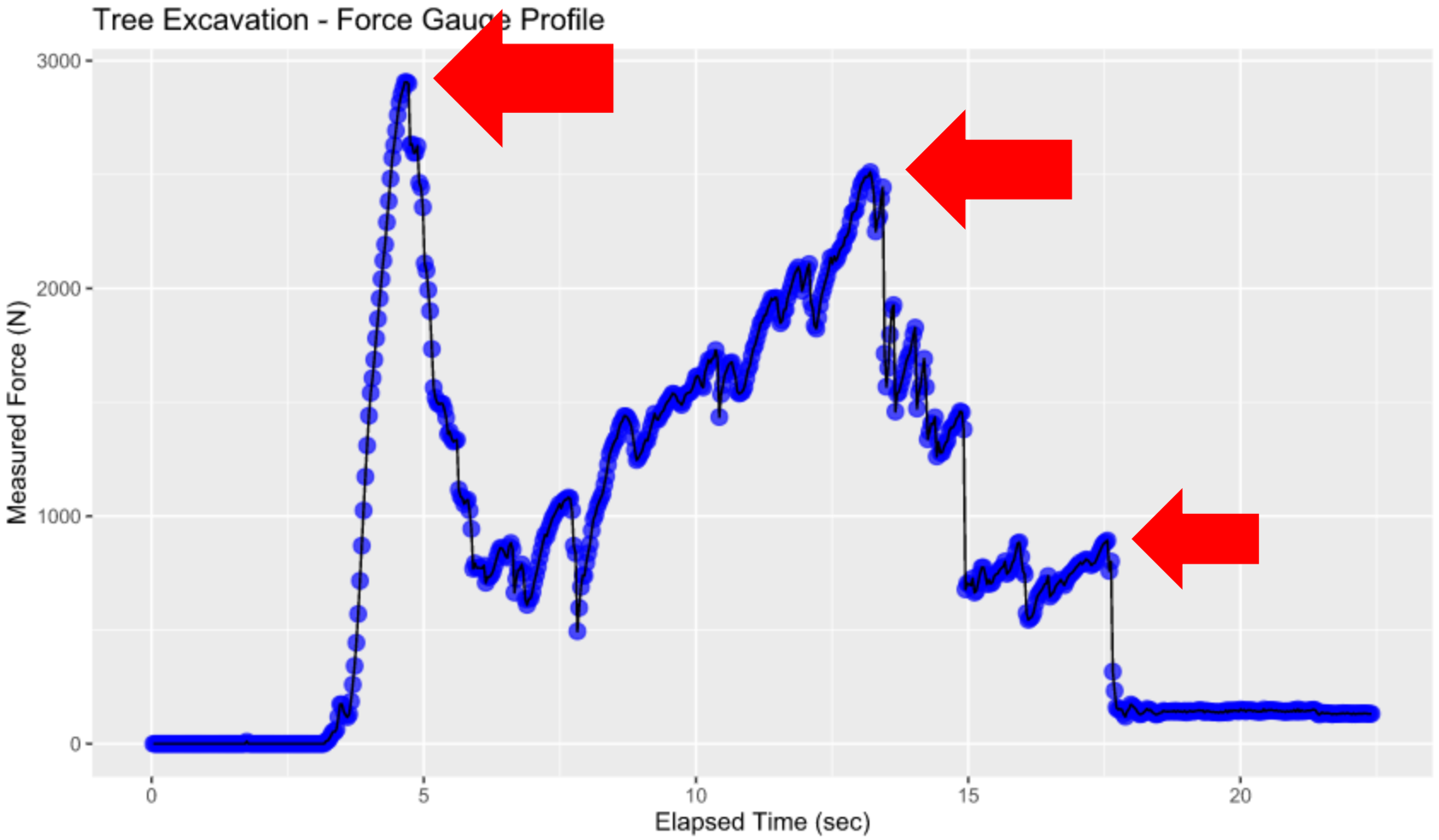
# Root mass fraction



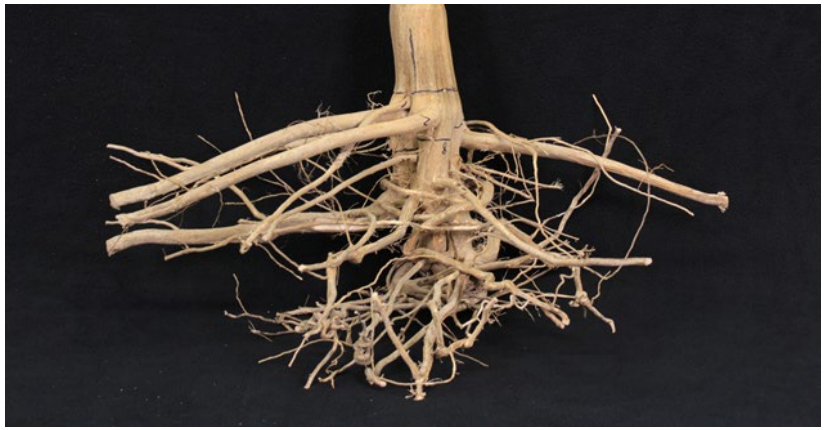

The propagation method did not influence the root mass fraction

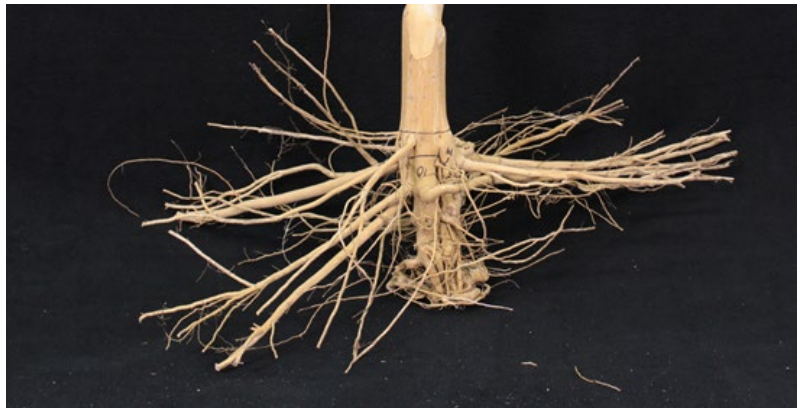
# OTHER OBSERVATIONS

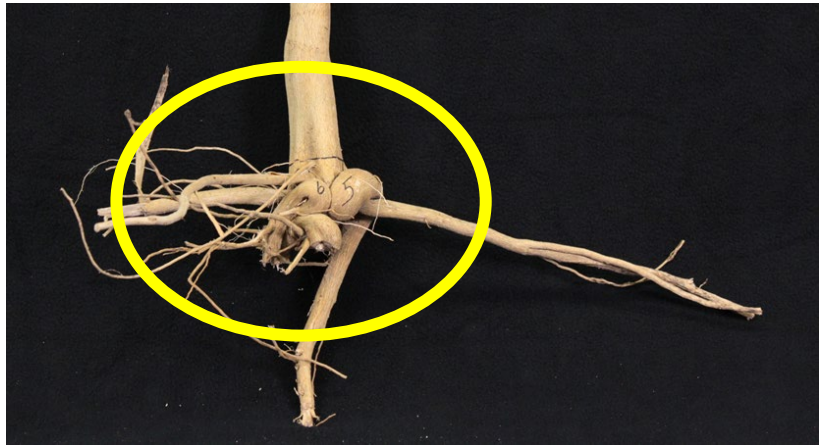
# Root structure and uprooting resistance



# Root system phenotypes







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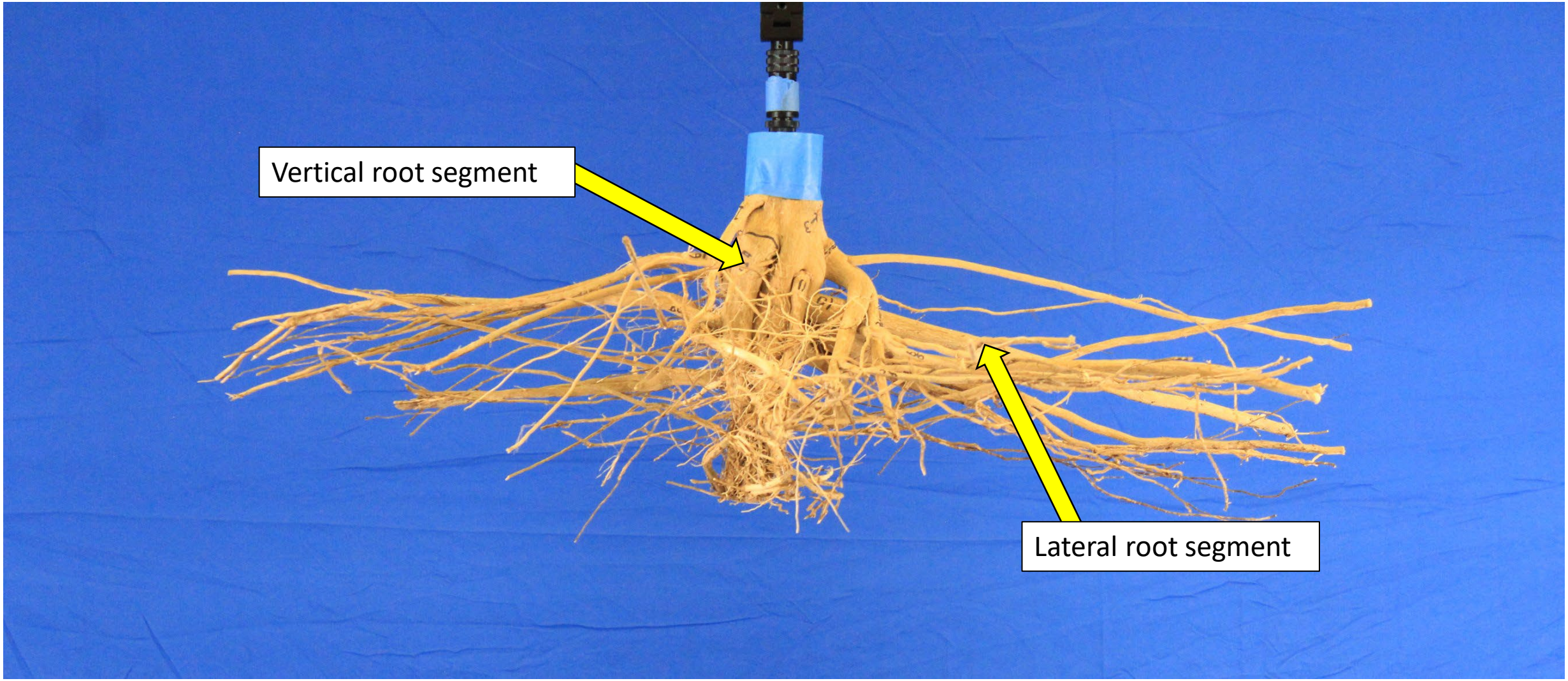

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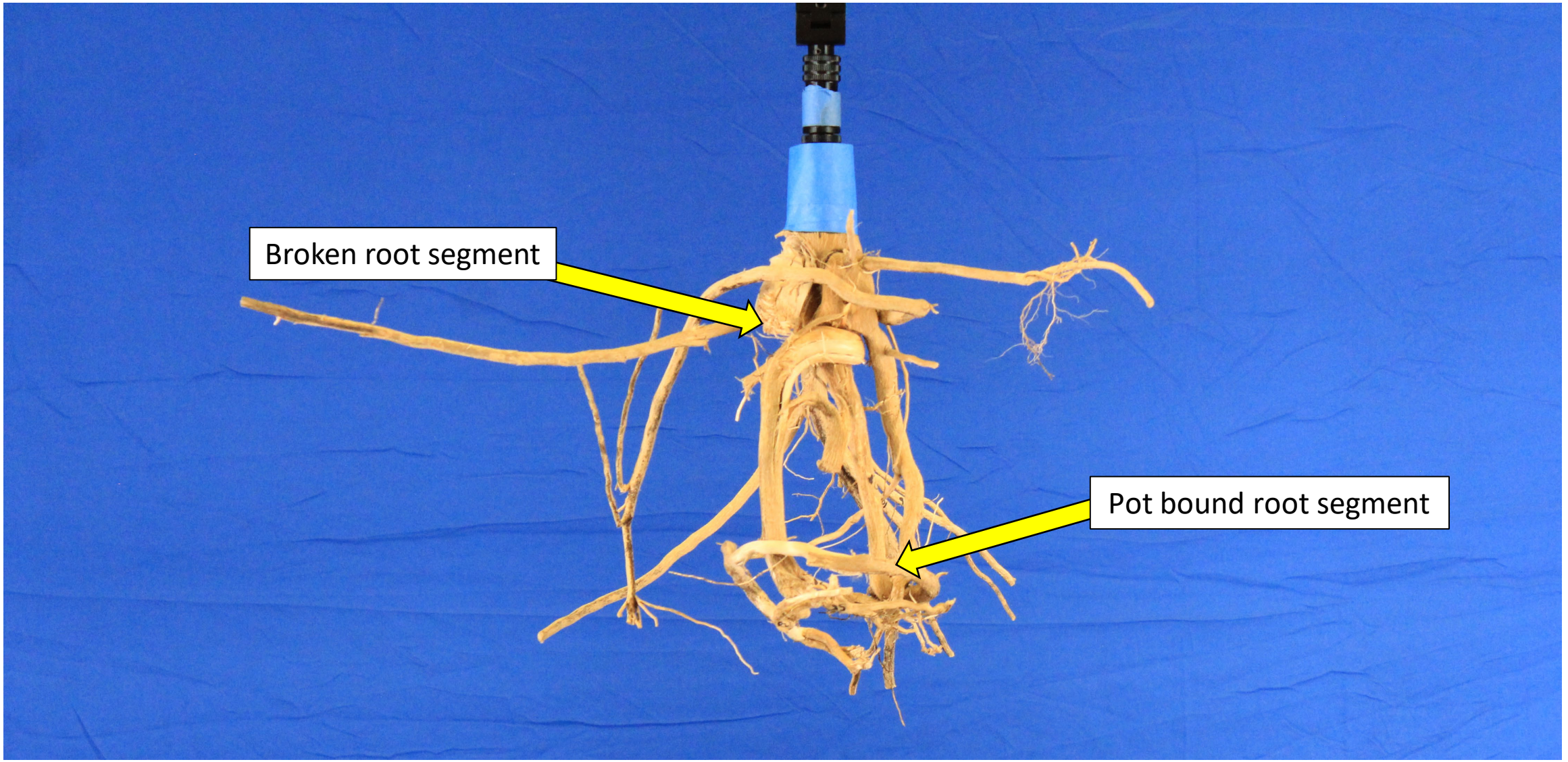

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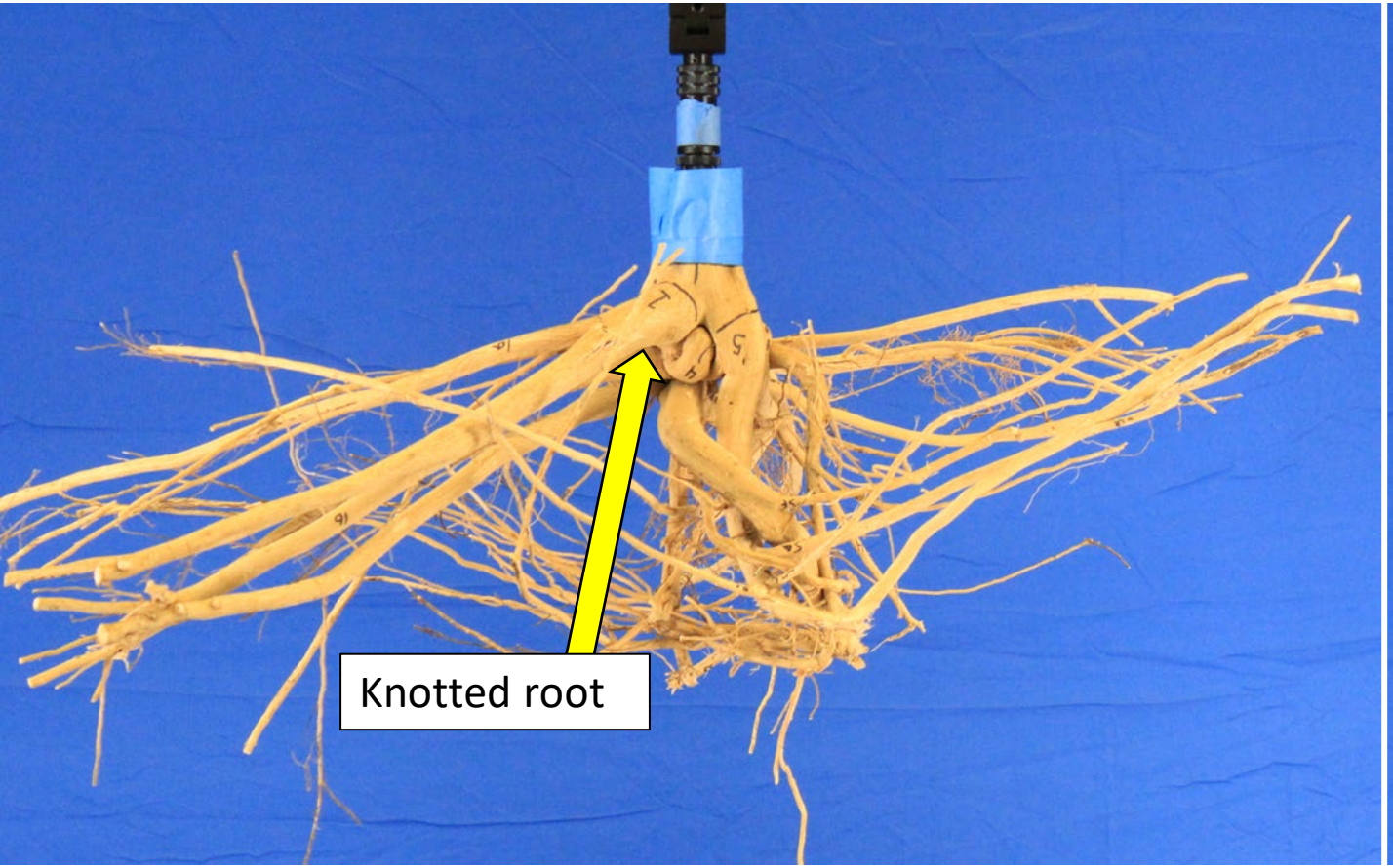
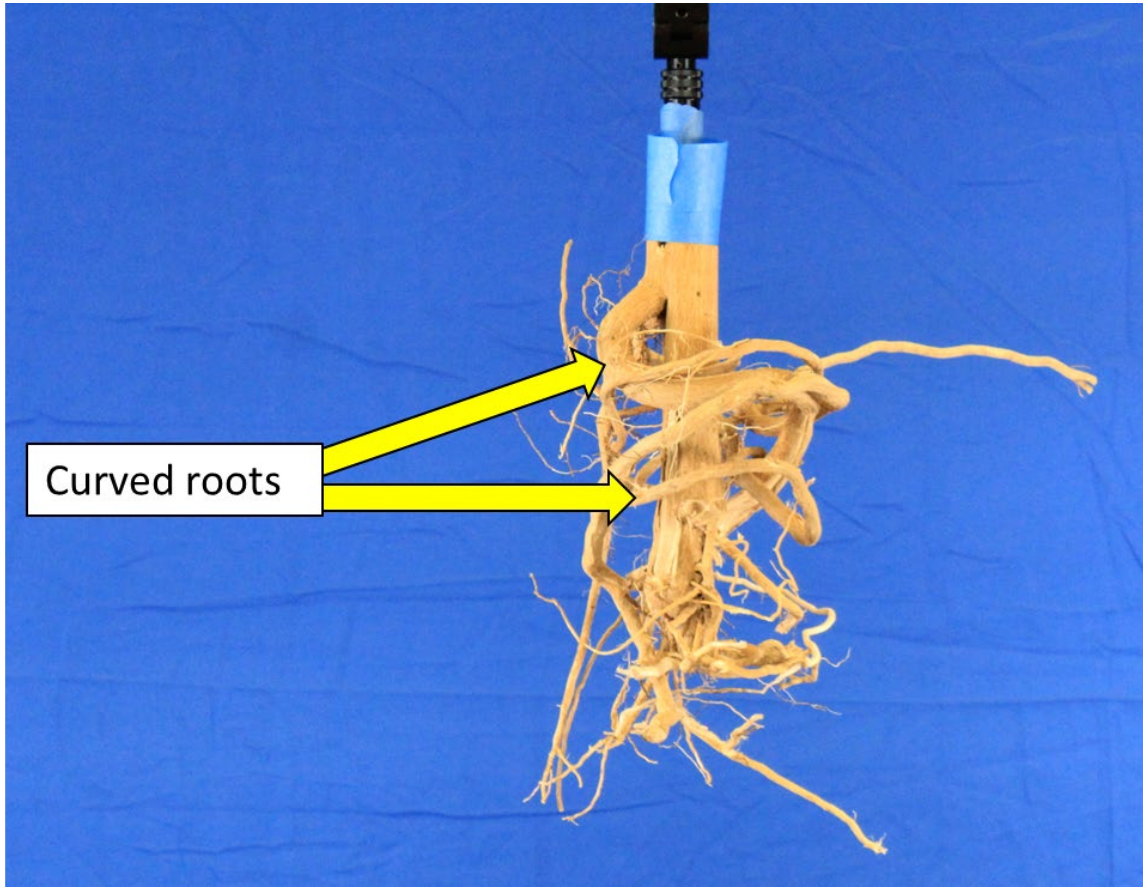


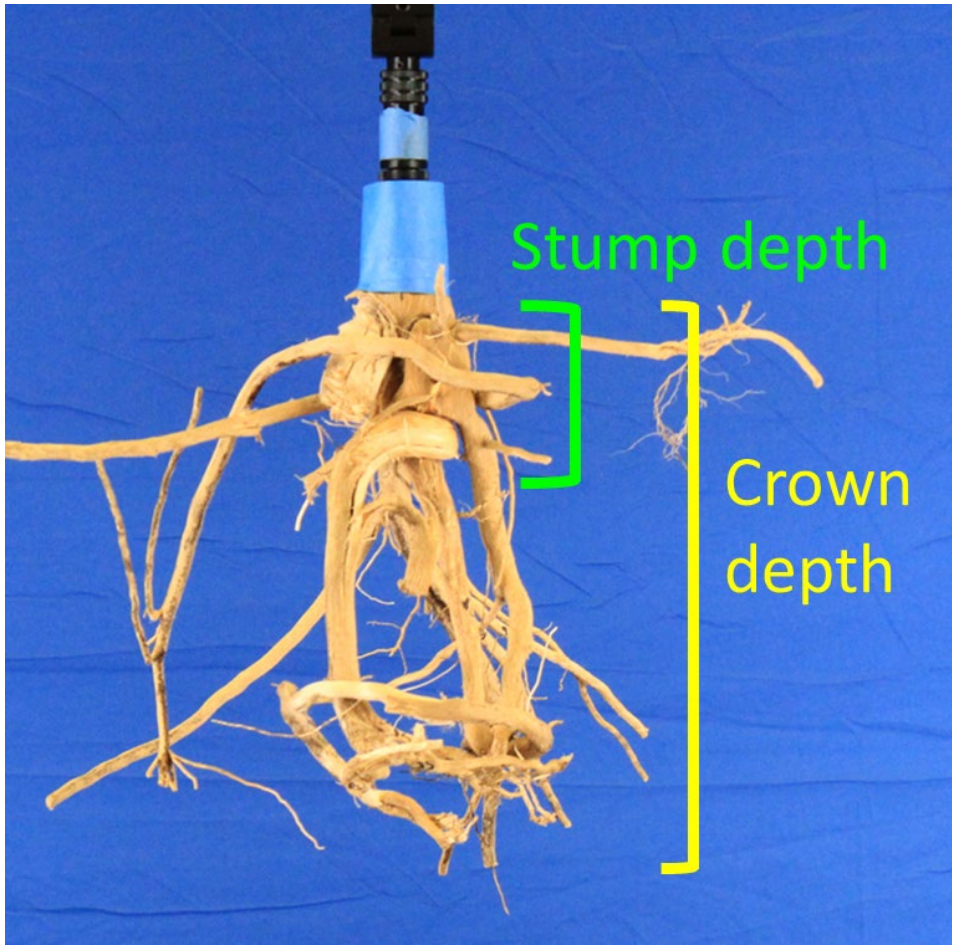



# Root segments

| | | Lateral (%) | Vertical (%) | Straight (%) | Curved (%) | Pot-bound (%) | Knotted (%) | Broken (%) |
|---|---|---|---|---|---|---|---|---|
| *TRIAL 1* | SD | 0.65 ab | 0.29 ab | 0.34 | 0.58 | 0.32 | 0.39 | 0.44 |
| | CT | 0.60 b | 0.35 a | 0.34 | 0.58 | 0.32 | 0.42 | 0.42 |
| | TC | 0.74 a | 0.23 b | 0.39 | 0.55 | 0.29 | 0.37 | 0.42 |
| | | * | *** | NS | NS | NS | NS | NS |
| *TRIAL 2* | SD | 0.68 b | 0.27 a | 0.29 | 0.62 | 0.28 | 0.42 | 0.42 |
| | CT | 0.71 ab | 0.26 a | 0.35 | 0.60 | 0.24 | 0.44 | 0.44 |
| | TC | 0.78 a | 0.18 b | 0.41 | 0.54 | 0.25 | 0.40 | 0.40 |
| | | * | *** | NS | NS | NS | NS | NS |

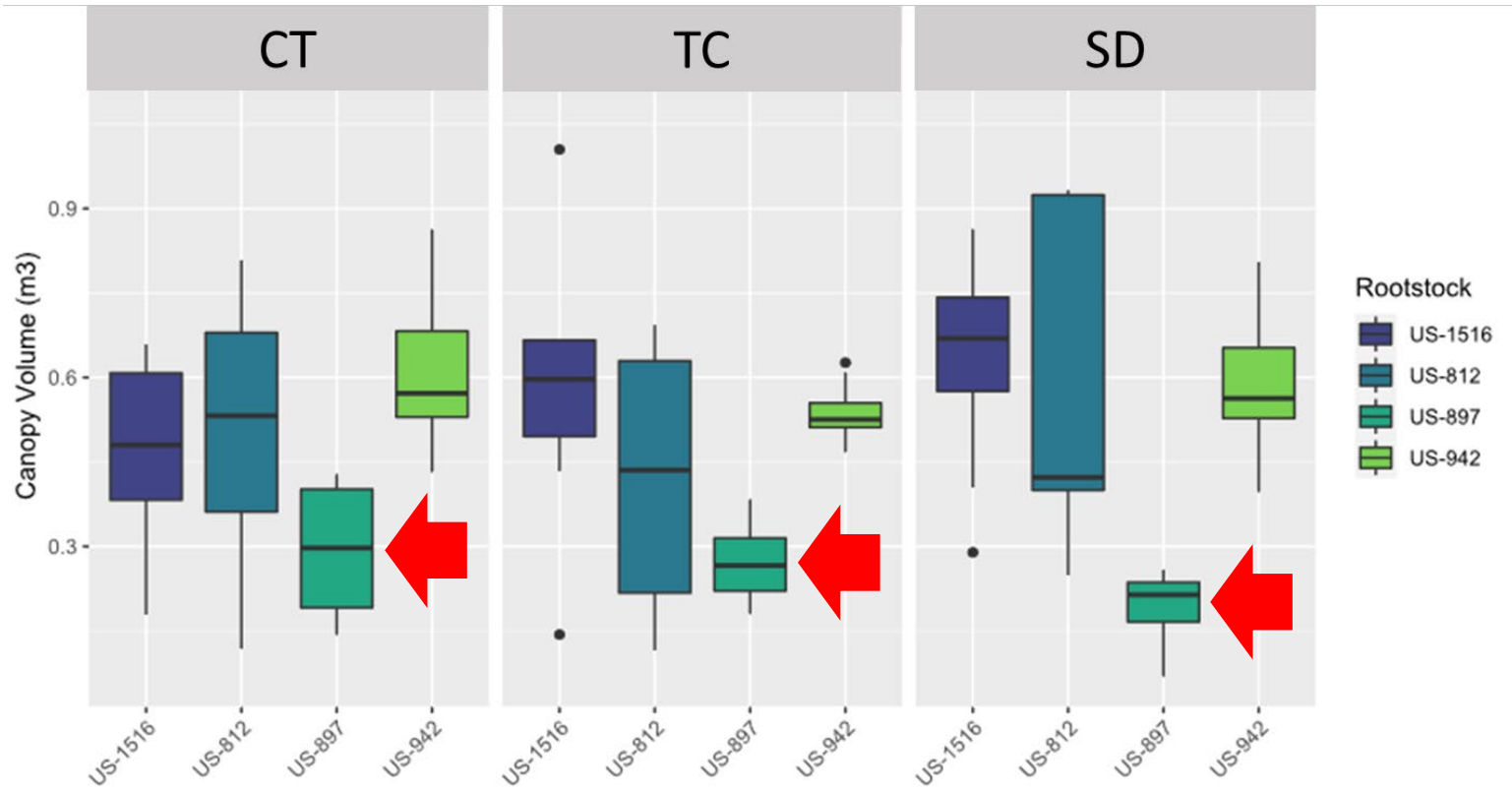
# Root crown and stump

| | | Crown depth (cm) | Stump depth (cm) | Crown weight (g) | Stump dia (cm) |
|---|---|---|---|---|---|
| *TRIAL 1* | SD | 26.0 | 22.0 a | 368 | 3.8 b |
| | CT | 26.1 | 19.6 b | 321 | 3.8 b |
| | TC | 25.7 | 9.9 c | 335 | 4.5 a |
| | | NS | *** | NS | *** |
| *TRIAL 2* | SD | 23.2 | 20.4 a | 333 | 4.0 b |
| | CT | 22.7 | 18.9 a | 369 | 4.1 b |
| | TC | 22.4 | 10.7 b | 364 | 4.9 a |
| | | NS | *** | NS | *** |



# Rootstock effects and other factors

- More differences found among **rootstocks** than among propagation methods
- Other factors (planting, soil environment, etc.) influence the root structure and therefore the grafted tree performance



# Thank You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Dr. Kim Bowman

USDA Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE

CRDF #18-028, CRDF #22-005

Nursery and Grower Collaborators